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This document discloses a granular-type soft magnetic type underlying film in which hard magnetic particles are used. Since fine particles of a hard magnetic type are used, the film exhibits hard magnetic properties at low temperature but soft magnetic properties at room temperature. By contrast, the present invention employs soft magnetic fine particles, and therefore it exhibits super magnetic properties at room temperature and soft magnetic properties at low temperature.

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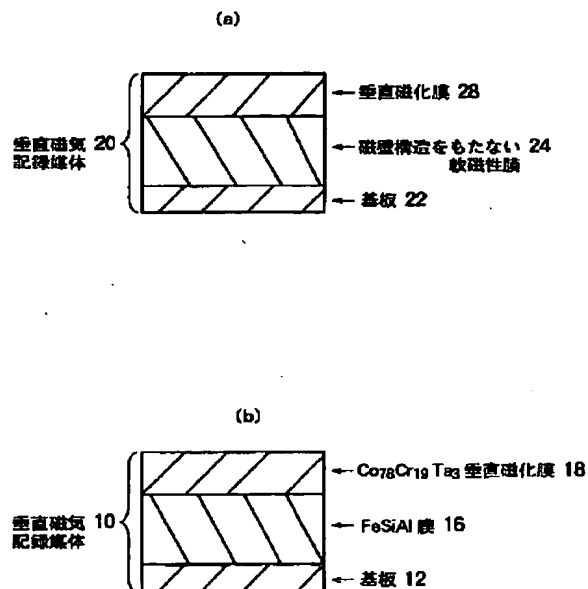
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(54) 【発明の名称】 垂直磁気記録媒体

(57) 【要約】

【課題】 記録再生時の優れたエンベロープ特性を有し、かつ下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁又は消磁現象が発生しない垂直磁気記録媒体を提供する。

【解決手段】 本垂直磁気記録媒体20は、基板22と、基板上に設けられた下地軟磁性膜24と、下地軟磁性膜上に設けられた垂直磁化膜28とを有する。下地軟磁性膜が、非磁壁構造として構成され、その保磁力が3000e以下である。本発明では、下地軟磁性膜が磁壁構造を有しないので、下地軟磁性膜が磁壁構造をとるときに発生する諸問題、即ち下地軟磁性膜の磁壁の上方を垂直磁気ヘッドが通過したときに発生する突発性の雑音、浮遊磁界によって下地軟磁性膜の磁壁が容易に移動し、記録磁化を減磁あるいは消磁してしまうという問題を解決することができ、エンベロープ特性の良好な低ノイズの垂直磁気記録媒体を実現できる。



## 【特許請求の範囲】

【請求項1】 基板と、基板上に設けられた軟磁性膜と、軟磁性膜上に設けられた垂直磁化膜とを少なくとも有する垂直磁気記録媒体において、軟磁性膜が、非磁壁構造として形成され、その保磁力が300Oe以下であることを特徴とする垂直磁気記録媒体。

【請求項2】 軟磁性膜が、FeSiAl又はFeSiAl系合金で形成されていることを特徴とする請求項1に記載の垂直磁気記録媒体。

【請求項3】 軟磁性膜が、FeTa<sub>N</sub>又はFeTa<sub>N</sub>系合金で形成されていることを特徴とする請求項1に記載の垂直磁気記録媒体。

【請求項4】 軟磁性膜が、グラニュー層薄膜として形成されていることを特徴とする請求項1に記載の垂直磁気記録媒体。

【請求項5】 SiO<sub>2</sub>、又はCをグラニュー層薄膜の母材とし、Co、CoPt及びCoCrPtのいずれかを母材中に分散させる粒子の材料とし、かつ母材を列、及び母在中に分散させる粒子の材料を行として構成した行列の行列要素のいずれかにより、グラニュー層薄膜が形成されていることを特徴とする請求項4に記載の垂直磁気記録媒体。

【請求項6】 膜厚100nm以下の接合層が、軟磁性膜と垂直磁化膜の間に介在していることを特徴とする請求項1から5のうちのいずれか1項に記載の垂直磁気記録媒体。

【請求項7】 接合層がCo<sub>1-x</sub>Cr<sub>x</sub> (0.25 ≤ x ≤ 0.60)、Ti及びCrTiのいずれかで形成されていることを特徴とする請求項6に記載の垂直磁気記録媒体。

【請求項8】 膜厚500nm以下のCr膜、V膜、及びCu膜のいずれかが、グラニュー層薄膜と基板の間に介在することを特徴とする請求項4から7のうちのいずれか1項に記載の垂直磁気記録媒体。

【請求項9】 グラニュー層薄膜が非磁壁構造であることを特徴とする請求項4から8のうちのいずれか1項に記載の垂直磁気記録媒体。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、磁気ディスク等として用いられる垂直磁気記録媒体に関し、更に詳細には、記録再生特性の良好な垂直磁気記録媒体に関するものである。

## 【0002】

【従来の技術】近年、パーソナルコンピュータやワークステーションの進歩に伴い、ハードディスクドライブが大容量化及び小型化しているため、磁気ディスクは、更なる高面記録密度化を必要としている。しかし、現在、広く普及している長手記録方式により高面記録密度を実

現しようとする、記録ビットの微細化に伴う記録磁化の熱揺らぎの問題や、記録ヘッドの記録能力を超えかねない高保磁力化の問題が発生する。そこで、これらの問題を解決しつつ、面記録密度を大幅に増大する手段として、垂直磁気記録方式が検討されていて、これを実現する垂直磁気記録媒体の一つとして、高透磁率の軟磁性膜と高い垂直異方性の垂直磁化膜からなる垂直2層媒体が提案されている。

【0003】以下に、図51を参照して、従来の垂直2層媒体の構成を説明する。図51は、従来の垂直磁気記録媒体の模式的基板断面図である。従来の垂直磁気記録媒体50は、図51に示すように、軟磁性裏打ち層52と垂直磁化膜54とを、順次、基板56上に形成してなるものである。例えば、軟磁性裏打ち層52にはNiFe膜、及び垂直磁化膜54にはCoCr系合金がそれぞれ用いられている（日本応用磁気学会誌、Vol. 8, No. 1, 1984, p17）。

## 【0004】

【発明が解決しようとする課題】しかし、図51に示したような従来の垂直磁気記録媒体には、以下に説明するような問題があった。第一の問題は、下地軟磁性膜52がプロットライン磁壁、とネール磁壁とに大別される磁壁（磁区）構造になっているために、垂直磁気記録媒体の記録再生の際に突発性の雑音（スパイクノイズ）が発生し、エンベロープ特性を劣化させて再生の忠実度を阻害することである。このような突発性の雑音は、下地軟磁性膜52に生じている磁壁の上方をヘッドが通過したときに発生する。第二の問題は、外部浮遊磁界による記録磁化の不安定性である。下地軟磁性膜52が磁壁構造になっているので、下地軟磁性層52内の磁壁が外部浮遊磁界により容易に移動する。そのような磁壁の移動が垂直磁気ヘッドの主磁極に対応する下地軟磁性層52内の領域で起こると、垂直記録層として機能する垂直磁化膜54に記録された磁化の減磁、あるいは消磁現象が発生する。このような外部からの浮遊磁界は、磁気ディスクと近接した位置に配置された磁気ディスクドライブ内のディスク回転用のモーターや、ヘッド位置決め用に用いられるモーターなどから発生する。これらの磁界は、極めて微弱であるものの、垂直磁気ヘッドの主磁極先端に集中すると、下地軟磁性膜の磁壁移動を誘発し、記録磁化を減磁あるいは消磁してしまうことがあるので、情報記憶装置としては致命的な欠陥となる。

【0005】そこで、本発明の目的は、記録再生時のエンベロープ特性が優れ、かつ下地軟磁性膜の磁壁の移動に由来する、突発性の雑音、及び記録磁化の減磁又は消磁現象が生じないような、新規な構成の垂直磁気記録媒体を提供することにある。

## 【0006】

【課題を解決するための手段】上記目的を達成するために、本発明に係る垂直磁気記録媒体は、基板と、基板上

に設けられた軟磁性膜と、軟磁性膜上に設けられた垂直磁化膜とを少なくとも有する垂直磁気記録媒体において、軟磁性膜が、非磁壁構造として形成され、その保磁力が3000e以下であることを特徴としている。本発明で、非磁壁構造の軟磁性膜とは、磁壁構造をもたない軟磁性膜を意味する。

【0007】非磁壁構造の軟磁性膜を成膜するには、FeSiAl又はFeSiAl系合金で軟磁性膜を成膜する。また、FeTa<sub>2</sub>N又はFeTa<sub>2</sub>N系合金で軟磁性膜を成膜しても良い。更には、グラニュー薄膜の軟磁性膜を成膜しても良い。その際には、SiO<sub>2</sub>、又はCをグラニュー薄膜の母材とし、Co、CoPt及びCoCrPtのいずれかを母材中に分散させる粒子の材料とし、かつ母材を列、母在中に分散させる粒子の材料を行として構成した行列の行列要素のいずれかでグラニュー薄膜が形成されている。

【0008】グラニュー薄膜は、母材中に他の物質を分散させているために、一般的には、表面平滑性があまり優れない。そこで、本発明の垂直磁気記録媒体では、好ましくは、軟磁性膜と垂直磁化膜の間に膜厚100nm以下の接合層を介在させる。これにより、軟磁性膜の表面平滑性の向上及び垂直磁化膜の垂直配向性の向上を同時に達成することができ、また、垂直磁化膜の磁気特性の角形比が改善され、低媒体ノイズ化を図ることができ、記録再生特性の良好な媒体とすることができる。その際には、Co<sub>1-x</sub>Cr<sub>x</sub> (0.25 ≤ x ≤ 0.60)、Ti及びCrTiのいずれかで接合層を形成するのが望ましい。

【0009】グラニュー薄膜を軟磁性膜とする垂直磁気記録媒体では、好適には、膜厚500nm以下のCr膜、V膜、及びCu膜のいずれかをグラニュー薄膜と基板の間に介在させる。これにより、Cr膜、V膜、又はCu膜を挿入しない場合に比べて、母材中に分散させた粒子の独立化を促進させることができるので、保磁力が増大して、再生出力の記録密度依存性の向上を図ることができ、記録再生特性の良好な媒体とすることが可能である。また、好適には、グラニュー薄膜を非磁壁構造とする。

【0010】磁壁構造は、プロットライン磁壁、とネール磁壁とに大別されているが、本発明に係る垂直磁気記録媒体は、軟磁性膜の成膜材料を特定することにより、そのような磁壁構造を有しない軟磁性膜を垂直磁化膜の下に備えている。従って、磁壁構造を有する軟磁性膜を用いた従来の垂直磁気記録媒体に発生していたような諸問題、即ち垂直磁気ヘッドが軟磁性膜に生じている磁壁の上方を通過したときに発生する突発性の雑音（スパイクノイズ）、或いはディスク回転用モーターやヘッド位置決め用モーターなどから発生する浮遊磁界によって軟磁性膜の磁壁が移動し、記録磁化を減磁あるいは消磁してしまうという問題を根本的に解決することができ、エ

ンペローブ特性の良好な低ノイズの媒体を実現できる。

#### 【0011】

【発明の実施の形態】以下に、実施形態例を挙げ、添付図面を参照して、本発明の実施の形態を具体的かつ詳細に説明する。

#### 実施形態例

本実施形態例は、本発明に係る垂直磁気記録媒体の実施形態の一つの例であって、図1(a)は本実施形態例の垂直磁気記録媒体の構成を示す模式的基板断面図である。本実施形態例の垂直磁気記録媒体20は、図1

(a)に示すように、基板22と、基板22上に、順次、形成された、非磁壁構造の下地軟磁性膜24、即ち磁壁構造を有しない下地軟磁性膜24と、垂直磁化膜28とかなる積層構造を備えている。FeSiAl膜又はFeSiAl系合金膜、FeTa<sub>2</sub>N膜又はFeTa<sub>2</sub>N系合金膜、更には、母材としてSiO<sub>2</sub>、又はCを、その母材中に分散させる粒子の材料としてCo、CoPt、又はCoCrPtを採用し、母材を列、母在中に分散させる粒子の材料を行とした行列の行列要素のいずれかで形成したグラニュー薄膜を用いることにより、磁壁構造を有しない下地軟磁性膜を形成することができる。

【0012】以上の構成により、本発明に係る垂直磁気記録媒体20は、下地軟磁性膜が磁壁構造をとるときに発生する前述した諸問題を根本的に解決することができる。

#### 【0013】

【実施例】以下に、実施例を挙げ、添付図面を参照して、本発明の実施の形態を具体的かつ詳細に説明する。

#### 実施例1

本実施例は、本発明に係る垂直磁気記録媒体の実施例の一つである。図1(b)は本実施形態例の垂直磁気記録媒体の構成を示す基板断面図である。本実施例の垂直磁気記録媒体10は、2.5インチの基板12と、基板12上に形成された膜厚500nmのFeSiAl膜からなる下地軟磁性膜16と、下地軟磁性膜16上に形成されたCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜(at%)からなる垂直磁化膜18と、C保護膜(図示せず)とを有する積層構造として形成されている。

【0014】以下に、本実施例の垂直磁気記録媒体10を作製する方法を説明する。まず、6インチのFeSiAlターゲットを用いて、スパッタ法により以下の成膜条件で2.5インチの基板12上に膜厚500nmのFeSiAl膜からなる下地軟磁性膜16を成膜した。

成膜条件

チャンバの初期真空度	: 5 × 10 <sup>-7</sup> Torr以下
基板温度	: 600℃
投入電力	: 0.5kw
アルゴンガス圧	: 4mTorr
成膜速度	: 3nm/sec

【0015】次いで、FeSiAl膜からなる下地軟磁

性膜16上に、 $\text{Co}_{78}\text{Cr}_{19}\text{Ta}_3(\text{at}\%)$ ターゲットを用いて基板温度 $200^\circ\text{C}$ で膜厚 $100\text{nm}$ の $\text{Co}_{78}\text{Cr}_{19}\text{Ta}_3$ 膜からなる垂直磁化膜18を成膜した。更に、 $\text{Co}_{78}\text{Cr}_{19}\text{Ta}_3$ 膜18の上に膜厚 $10\text{nm}$ のC保護膜を成膜し、得た垂直磁気記録媒体を本発明媒体A2とした。また、保磁力の比較用に基板温度を室温にして成膜した $\text{FeSiAl}$ 膜も作製した。

【0016】一方、本発明媒体A2とは別に、 $\text{FeSiAl}$ 膜の代わりに、 $\text{NiFe}$ ターゲットを用いて、実施例1と同様にして、 $\text{NiFe}$ 膜からなる下地軟磁性膜、及び $\text{Co}_{78}\text{Cr}_{19}\text{Ta}_3(\text{at}\%)$ 膜を成膜した媒体を従来媒体A1とした。

【0017】本発明に係る垂直磁気記録媒体A2を評価するために、以下のようにして、磁壁構造の観察、保磁力の測定、記録再生特性の測定等を行った。実施例2以下の実施例にも同じ評価方法を適用した。本発明媒体A2の $\text{FeSiAl}$ 膜16の磁壁構造を調べるために、以下のようにして、粉末図形法により磁壁構造を観察した。まず、基板温度 $600^\circ\text{C}$ で成膜した $\text{FeSiAl}$ 膜の表面に微少な傷をつけ、磁壁構造を見え易くした後、ビッター液(磁性コロイド)をその上に塗布した。そして、その試料を磁壁観察用電磁石にセットし、金属顕微鏡で磁壁構造を観察したが、明瞭な磁壁構造は観察されなかった。次に、磁場を徐々に試料に印加しながら観察したところ、変化は見られなかった。これは、基板温度を室温にして成膜した $\text{FeSiAl}$ 膜についても同様であった。次いで、同様にして、従来媒体A1の $\text{NiFe}$ 膜を観察したところ、明瞭な磁壁構造が観察された。そして、試料に徐々に磁場を印加しながら観察したところ、磁壁の移動の様子が明瞭に観察された。以上のことは、 $\text{NiFe}$ 膜の磁化過程は磁壁移動による磁化過程であるのに対し、 $\text{FeSiAl}$ 膜の磁化過程は磁壁移動によらないことを示している。

【0018】次に、 $\text{FeSiAl}$ 膜及び $\text{NiFe}$ 膜の保磁力を調べるために、試料振動型磁力計(VSM)を用いて保磁力の測定を行った。その結果、基板温度 $600^\circ\text{C}$ で成膜した $\text{FeSiAl}$ 膜及び $\text{NiFe}$ 膜の保磁力はそれぞれ $0.1\text{Oe}$ 、基板温度を室温にして成膜した $\text{FeSiAl}$ 膜の保磁力は $3000\text{Oe}$ であった。

【0019】単磁極ヘッド及びID/MR複合ヘッドを用いて、本発明媒体A2及び従来媒体A1について記録再生の評価試験を行った。ここで、ID/MR複合ヘッド記録トラック幅は $4\mu\text{m}$ 、再生トラック幅は $3\mu\text{m}$ 、記録ギャップ長は $0.4\mu\text{m}$ 、再生ギャップ長は $0.32\mu\text{m}$ であった。また、単磁極ヘッドのトラック幅は $10\mu\text{m}$ 、主磁極膜厚は $0.4\mu\text{m}$ であった。評価試験は、記録電流 $10\text{mA}$ 、センス電流 $12\text{mA}$ 、周速度 $12.7\text{m/sec}$ 、浮上量 $45\text{nm}$ 、及びノイズのバンド帯域 $45\text{MHz}$ の条件下で行った。なお、実験は単磁極ヘッドによって記録した信号をMRヘッドで読み出す場合

と、IDヘッドで記録した信号をMRヘッドで読み出す場合の両方について行った。図2は、本発明媒体A2及び従来媒体A1エンベロープ特性を示す。図2に示すように、本発明媒体A2は、従来媒体A1と比較して、遥かにエンベロープがきれいであり、エンベロープ特性が非常に優れていることが分かる。この評価試験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す評価試験も行ったところ、同様なエンベロープ特性の違いが見られた。

【0020】このことは、従来媒体A1の下地軟磁性膜 $\text{NiFe}$ は磁壁構造をとるため、磁壁の移動にともなう突発性の雑音が見られるのに対し、本発明媒体A2の下地軟磁性膜 $\text{FeSiAl}$ は磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、 $\text{FeSiAl}$ 膜を室温で成膜した膜を下地に持つ媒体の結果も同様なものになる。何故ならば、元来、磁性体は保磁力が大きければ磁壁構造は出来難いからであり、この場合、室温で成膜した $\text{FeSiAl}$ 膜の保磁力は、基板温度 $600^\circ\text{C}$ で成膜した $\text{FeSiAl}$ 膜の保磁力よりも遥かに大きく、磁壁構造が一層出来難い状態にあるからである。

【0021】次に、本発明媒体A2及び従来媒体A1について、次のようにして、外部浮遊磁界に対する記録磁化の安定性を評価した。単磁極ヘッドにより信号を本発明媒体A2及び従来媒体A1に記録した後、ヘルムホルツコイルによって媒体に直流磁場を大きさ $0.1\sim 5000\text{Oe}$ の範囲で印加し、磁場印加前の再生出力と磁場印加後の再生出力の比較を行い、その結果を図3に示した。図3は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示している。図3から分かるように、従来媒体A1は、下地軟磁性膜の保磁力に相当する $0.1\text{Oe}$ を印加した段階で記録磁化の減磁に伴う再生出力の低下が見られ、印加磁場を大きくするのに伴って減磁量が増加するのに対し、本発明媒体A2は $5000\text{Oe}$ の磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体A2の方が遥かに優れていることが分かった。また、IDヘッドで記録した信号をMRヘッドで読み出す方法によって、同様の実験を行ったところ、全く同様な傾向が見られた。この結果を図4に示す。この場合も、図2のところで述べたような理由によって、 $\text{FeSiAl}$ 膜を室温で成膜した膜を下地に持つ媒体の外部浮遊磁界に対する記録磁化の安定性の結果は同様なものになる。しかし、室温で成膜した $\text{FeSiAl}$ 膜は保磁力が $3000\text{Oe}$ と大きいため、矩形波状の再生波形に歪みが生じる。垂直2層媒体の下地軟磁性層として機能し、矩形状の再生波形を得るためには、下地軟磁性膜 $\text{FeSiAl}$ の保磁力は $1000\text{Oe}$ 以下であることが望ましい。

【0022】次に、記録磁化の経時変化を調べるため

に、本発明媒体A2及び従来媒体A1に信号を単磁極ヘッドにより記録した後、単磁極ヘッドを媒体上にロードさせたままで再生出力を測定した。記録直後の再生出力を $t = 1$ 秒とし、 $t = 1 \times 10^4$ 秒まで測定した。そして、 $t = 1$ 秒の時の再生出力と一定時間経過後の再生出力の比較を行い、その結果を図5に示した。図5は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示している。図5から分かるように、従来媒体A1は、信号記録後の経過時間の対数にほぼ比例して再生出力が低下するのに対し、本発明媒体A2では、このような再生出力の低下は全く見られなかった。このことは、NiFeの磁壁が地磁気やディスク回転用モーターなどの微少な磁場によっても容易に移動し、それが垂直磁気ヘッドの主磁極と対応する領域で起こったために記録磁化の減磁が見られたと考えられる。一方、本発明媒体A2に用いているFeSiAl膜は磁壁構造をとらないために、このような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、この場合も、図2のところで述べたような理由によって、FeSiAl膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。

【0023】以上のことから、本発明媒体A2を用いることによって記録再生時のエンベロップ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

#### 【0024】実施例2

FeSiAlRuTi膜ターゲットを用いて、下地軟磁性膜としてFeSiAlRuTi膜を基板上に成膜したことを除いて、実施例1の本発明媒体A2と同様にし、垂直磁気記録媒体を作製し、本発明媒体B2とした。また、保磁力の比較のために、基板温度を室温にして成膜したFeSiAlRuTi膜も作製した。

【0025】本発明媒体B2のFeSiAlRuTi膜を観察したところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したFeSiAlRuTi膜についても同様であった。以上のことは、本発明媒体B2のFeSiAlRuTi膜の磁化過程は磁壁移動によらないことを示している。

【0026】次に、本発明媒体B2のFeSiAlRuTi膜の保磁力を調べたところ、保磁力は0.1Oeであった。また、基板温度を室温にして成膜したFeSiAlRuTi膜の保磁力は3000Oeであった。

【0027】本発明媒体B2について記録再生特性の評価試験を行い、従来媒体A1と比較したところ、実施例1の本発明媒体A2と同様に、本発明媒体B2は、従来媒体A1に比較して遥かにエンベロップがきれいであり、エンベロップ特性が非常に優れていることが分かった。この評価試験は、単磁極ヘッドによって記録した信

号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す実験も行ったところ、同様なエンベロップ特性の違いが見られた。

【0028】このことは、本発明媒体B2の下地軟磁性膜FeSiAlRuTiは磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、FeSiAlRuTi膜を室温で成膜した膜を下地に持つ媒体の結果も同様なものになる。

【0029】次に、本発明媒体B2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A1と対比して、図6に示した。図6は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示してある。図6から分かるように、再生出力が低下する従来媒体A1に対して、本発明媒体B2は500Oeの磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体B2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行ったところ、全く同様な傾向が見られた。この結果を図7に示す。また、実施例1のところで述べたような理由によって、FeSiAlRuTi膜を室温で成膜した膜を下地に持つ媒体の外部浮遊磁界に対する記録磁化の安定性の結果は同様なものになる。

【0030】次に、記録磁化の経時変化を測定し、従来媒体A1と対比して、図8に示した。図8は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示している。図8から分かるように、再生出力が低下する従来媒体A1に対して、本発明媒体B2では、このような再生出力の低下は全く見られなかった。このことは、本発明媒体B2に用いているFeSiAlRuTi膜は磁壁構造をとらないために、このような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたような理由によって、FeSiAlRuTi膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。

【0031】以上のことより、本発明媒体B2を用いることによって記録再生時のエンベロップ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

#### 【0032】実施例3

FeTaN膜ターゲットを用いて、下地軟磁性膜としてFeTaN膜を基板上に成膜したことを除いて、実施例1と同様にし、垂直磁気記録媒体を作製し、本発明媒体Q2とした。また、保磁力の比較のために基板温度を室温にして成膜したFeTaN膜も作製した。

【0033】本発明媒体Q2のFeTaN膜を観察した

ところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したFeTa<sub>2</sub>N膜についても同様であった。以上のことは、FeTa<sub>2</sub>N膜の磁化過程は磁壁移動によらないことを示している。

【0034】次に、本発明媒体Q2おFeTa<sub>2</sub>N膜の保磁力を測定したところ、保磁力は0.1Oeであった。また、基板温度を室温にして成膜したFeTa<sub>2</sub>N膜の保磁力は300Oeであった。

【0035】本発明媒体Q2について記録再生特性の評価試験を行い、本発明媒体Q2と従来媒体A1とのエンベロープ特性を比較したところ、実施例1の本発明媒体A2と同様に、本発明媒体Q2は、従来媒体A1に比較して遥かにエンベロープがきれいであり、エンベロープ特性が非常に優れていることが分かった。この試験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す実験も行ったところ、同様なエンベロープ特性の違いが見られた。このことは、本発明媒体Q2の下地軟磁性膜FeTa<sub>2</sub>Nは磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、FeTa<sub>2</sub>N膜を室温で成膜した膜を下地に持つ媒体の結果も同様なものになる。

【0036】次に、本発明媒体Q2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A1と対比して、図52に示した。図52は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示している。図52から分かるように、再生出力が低下する従来媒体A1に対し、本発明媒体Q2は500Oeの磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体Q2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行ったところ、全く同様な傾向が見られた。この結果を図53に示す。また、実施例1のところで述べたような理由によって、FeTa<sub>2</sub>N膜を室温で成膜した膜を下地に持つ媒体の外部浮遊磁界に対する記録磁化の安定性の結果は同様なものになる。

【0037】次に、本発明媒体Q2の記録磁化の経時変化を測定し、従来媒体A1と対比して、図54に示した。図54は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示している。図54から分かるように、再生出力が低下する従来媒体A1に対して、本発明媒体Q2では、このような再生出力の低下は全く見られなかった。本発明媒体Q2に用いているFeTa<sub>2</sub>N膜は磁壁構造をとらないために、このような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたよう

な理由によって、FeTa<sub>2</sub>N膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。以上のことより、本発明媒体Q2を用いることによって記録再生時のエンベロープ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

#### 【0038】実施例4

分散膜中のCoの体積比を50%程度に設定し、CoターゲットとSiO<sub>2</sub>ターゲットを用いて、基板にバイアス電圧を印加しながら実施例1と同じ成膜条件で、同時にスパッタし、基板上に膜厚500nmのCo-SiO<sub>2</sub>分散膜を下地軟磁性膜として成膜したこと除いて、実施例1と同様にして垂直磁気記録媒体を作製し、本発明媒体C2とした。また、保磁力の比較のために、基板温度を室温にして成膜したCo-SiO<sub>2</sub>分散膜も作製した。

【0039】Co-SiO<sub>2</sub>分散膜を観察したところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したCo-SiO<sub>2</sub>分散膜についても同様であった。以上のことは、NiFe膜の磁化過程は磁壁移動による磁化過程であるのに対し、本発明媒体C2のCo-SiO<sub>2</sub>分散膜の磁化過程は磁壁移動によらないことを示している。

【0040】次に、Co-SiO<sub>2</sub>分散膜の保磁力を測定したところ、本発明媒体C2のCo-SiO<sub>2</sub>分散膜は0.1Oe、及び基板温度を室温にして成膜したCo-SiO<sub>2</sub>分散膜の保磁力は300Oeであった。

【0041】本発明媒体C2について記録再生特性の評価試験を行い、本発明媒体C2と従来媒体A1とのエンベロープ特性を比較したところ、実施例1の本発明媒体A2と同様に、本発明媒体C2は、従来媒体A1に比較して遥かにエンベロープがきれいであり、エンベロープ特性が非常に優れていることが分かった。この実験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す実験も行ったところ、同様なエンベロープ特性の違いが見られた。このことは、本発明媒体C2の下地軟磁性膜であるCo-SiO<sub>2</sub>分散膜は磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、Co-SiO<sub>2</sub>分散膜を室温で成膜した膜を下地に持つ媒体の結果も同様なものになる。

【0042】次に、本発明媒体C2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A1と対比して、図9に示した。図9は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示してある。再生出力が低下する従来媒体A1に対して、図9から分かる

ように、本発明媒体C2は5000eの磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体C2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行ったところ、全く同様な傾向が見られた。この結果を図10に示す。また、実施例1のところで述べたような理由によって、Co-SiO<sub>2</sub>分散膜を室温で成膜した膜を下地に持つ媒体の外部浮遊磁界に対する記録磁化の安定性の結果は同様なものになる。

【0043】次に、本発明媒体C2の記録磁化の経時変化を測定し、従来媒体A1と対比して、図11に示した。図11は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示してある。図11から分かるように、再生出力が低下する従来媒体A1に対して、本発明媒体C2では、このような再生出力の低下は全く見られなかった。それは、本発明媒体B2に用いているCo-SiO<sub>2</sub>分散膜は磁壁構造をとらないために、このような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたような理由によって、Co-SiO<sub>2</sub>分散膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。以上のことより、本発明媒体C2を用いることによって記録再生時のエンベロップ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

【0044】実施例5  
分散膜中のCoの体積比を50%程度に設定し、CoターゲットとCターゲットを用いて、基板にバイアス電圧を印加しながら実施例1と同じ成膜条件で、同時にスパッタし、基板上にCo-C分散膜を下地軟磁性膜として成膜したこと除いて、実施例1と同様にして垂直磁気記録媒体を作製し、本発明媒体D2とした。

【0045】本発明媒体D2のCo-C分散膜を観察したところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したCo-C分散膜についても同様であった。以上のことは、Co-C分散膜の磁化過程は磁壁移動によらないことを示している。

【0046】Co-C分散膜の保磁力を調べたところ、本発明媒体D2のCo-C分散膜は0.10e、基板温度を室温にして成膜したCo-C分散膜の保磁力は3000eであった。

【0047】本発明媒体D2について記録再生特性の評価試験を行い、本発明媒体D2と従来媒体A1とのエンベロップ特性を比較したところ、実施例1の本発明媒体A2と同様に、本発明媒体D2は、従来媒体A1に比較して遥かにエンベロップがきれいであり、エンベロップ

特性が非常に優れていることが分かった。この実験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す実験も行ったところ、同様なエンベロップ特性の違いが見られた。このことは、本発明媒体D2の下地軟磁性膜であるCo-C分散膜は磁区構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、Co-C分散膜を室温で成膜した膜を下地に持つ媒体の結果も同様なものになる。

【0048】本発明媒体D2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A1と対比して、図12に示した。図12は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示してある。図12から分かるように、再生出力が低下する従来媒体A1に対して、本発明媒体D2は5000eの磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体D2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行ったところ、全く同様な傾向が見られた。この結果を図13に示す。また、実施例1のところで述べたような理由によって、Co-C分散膜を室温で成膜した膜を下地に持つ媒体の外部浮遊磁界に対する記録磁化の安定性の結果は同様なものになる。

【0049】本発明媒体D2の記録磁化の経時変化を測定し、従来媒体A1と対比して、図14に示した。図14は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示してある。再生出力が低下する従来媒体A1に対して、図14から分かるように、本発明媒体D2では、このような再生出力の低下は全く見られなかった。本発明媒体D2に用いているCo-C分散膜は磁壁構造をとらないために、従来媒体A1のような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたような理由によって、Co-C分散膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。以上のことより、本発明媒体D2を用いることによって記録再生時のエンベロップ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

【0050】実施例6  
分散膜中のCoPtの体積比を50%程度に設定し、CoPtターゲットとSiO<sub>2</sub>ターゲットを用いて、基板にバイアス電圧を印加しながら実施例1と同じ成膜条件で、同時にスパッタし、基板上に膜厚500nmのCoPt-SiO<sub>2</sub>分散膜を下地軟磁性膜として成膜したこと除いて、実施例1と同様にして垂直磁気記録媒体を作製し、本発明媒体E2とした。

【0051】C o P t - S i O<sub>2</sub>分散膜を観察したところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したC o P t - S i O<sub>2</sub>分散膜についても同様であった。以上のことは、C o P t - S i O<sub>2</sub>分散膜の磁化過程は磁壁移動によらないことを示している。

【0052】C o P t - S i O<sub>2</sub>分散膜の保磁力を測定したところ、本発明媒体E 2のC o P t - S i O<sub>2</sub>分散膜は0.10e、基板温度を室温にして成膜したC o P t - S i O<sub>2</sub>分散膜の保磁力は3000eであった。

【0053】本発明媒体E 2について記録再生特性の評価試験を行い、本発明媒体E 2と従来媒体A 1とのエンベロープ特性を比較したところ、実施例1の本発明媒体A 2と同様に、本発明媒体E 2は、従来媒体A 1に比較して遥かにエンベロープがきれいであり、エンベロープ特性が非常に優れていることが分かった。この実験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す実験も行ったところ、同様なエンベロープ特性の違いが見られた。このことは、本発明媒体E 2の地下軟磁性膜であるC o P t - S i O<sub>2</sub>分散膜は磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、C o P t - S i O<sub>2</sub>分散膜を室温で成膜した膜を下地を持つ媒体の結果も同様なものになる。

【0054】本発明媒体E 2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A 1と対比して、図15に示した。図15は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示してある。再生出力が低下する従来媒体A 1に対して、図15から分かるように、本発明媒体E 2は5000eの磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体E 2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行ったところ、全く同様な傾向が見られた。この結果を図16に示す。また、実施例1のところで述べたような理由によって、C o P t - S i O<sub>2</sub>分散膜を室温で成膜した膜を下地を持つ媒体の外部浮遊磁界に対する記録磁化の安定性の結果は同様なものになる。

【0055】次に、本発明媒体D 2の記録磁化の経時変化を測定し、従来媒体A 1と対比して、図17に示した。図17は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示してある。再生出力が低下する従来媒体A 1に対して、図17から分かるように、本発明媒体E 2では、このような再生出力の低下は全く見られなかった。本発明媒体E 2に用いているC o P t - S i O<sub>2</sub>分散膜は磁壁構造をとらないために、従

来媒体A 1のような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたような理由によって、C o P t - S i O<sub>2</sub>分散膜を室温で成膜した膜を下地を持つ媒体の記録磁化の経時変化の結果は同様なものになる。以上のことより、本発明媒体E 2を用いることによって記録再生時のエンベロープ特性の向上並びに地下軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

#### 【0056】実施例7

分散膜中のC o P tの体積比を50%程度に設定し、C o P tターゲットとCターゲットを用いて、基板にバイアス電圧を印加しながら実施例1と同じ成膜条件で、同時にスパッタし、基板上に膜厚500nmのC o P t - C分散膜を下地軟磁性膜として成膜したこと除いて、実施例1と同様にして垂直磁気記録媒体を作製し、本発明媒体F 2とした。

【0057】C o P t - C分散膜を観察したところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したC o P t - C分散膜についても同様であった。以上のことは、C o P t - C分散膜の磁化過程は磁壁移動によらないことを示している。

【0058】次に、C o P t - C分散膜の保磁力を測定したところ、本発明媒体F 2の保磁力は0.10e、基板温度を室温にして成膜したC o P t - C分散膜の保磁力は3000eであった。

【0059】本発明媒体F 2の記録再生特性の評価試験を行い、本発明媒体F 2と従来媒体A 1のエンベロープ特性を調べたところ、本発明媒体A 2と同様に、本発明媒体F 2は、従来媒体A 1に比較して遥かにエンベロープがきれいであり、エンベロープ特性が非常に優れていることが分かった。この実験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す実験も行ったところ、同様なエンベロープ特性の違いが見られた。このことは、本発明媒体F 2の地下軟磁性膜であるC o P t - C分散膜は磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、C o P t - C分散膜を室温で成膜した膜を下地を持つ媒体の結果も同様なものになる。

【0060】本発明媒体F 2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A 1と対比して、図18に示した。図18は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示してある。再生出力が低下する従来媒体A 1に対して、図18から分かるように、本発明媒体F 2は5000eの磁場を印加して

も減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体F2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行ったところ、全く同様な傾向が見られた。この結果を図19に示す。

【0061】次に、本発明媒体F2の記録磁化の経時変化を測定し、従来媒体A1と対比して、図20に示した。図20は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示してある。再生出力が低下する従来媒体A1に対して、図20から分かるように、本発明媒体F2では、このような再生出力の低下は全く見られなかった。本発明媒体F2に用いているCoPt-C分散膜は磁壁構造をとらないために、従来媒体A1のような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたような理由によって、CoPt-C分散膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。

【0062】以上のことより、本発明媒体F2を用いることによって記録再生時のエンベロップ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

#### 【0063】実施例8

分散膜中のCoCrPtの体積比を50%程度に設定し、CoCrPtターゲットとSiO<sub>2</sub>ターゲットを用いて、基板にバイアス電圧を印加しながら実施例1と同じ成膜条件で、同時にスパッタし、基板上に膜厚500nmのCoCrPt-SiO<sub>2</sub>分散膜を下地軟磁性膜として成膜したこと除いて、実施例1と同様にして垂直磁気記録媒体を作製し、本発明媒体G2とした。

【0064】CoCrPt-SiO<sub>2</sub>分散膜を観察したところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したCoCrPt-SiO<sub>2</sub>分散膜についても同様であった。以上のことは、CoCrPt-SiO<sub>2</sub>分散膜の磁化過程は磁壁移動によらないことを示している。

【0065】次に、CoCrPt-SiO<sub>2</sub>分散膜の保磁力を測定したところ、本発明媒体G2の保磁力は0.10e、基板温度を室温にして成膜したCoCrPt-SiO<sub>2</sub>分散膜の保磁力は3000eであった。

【0066】本発明媒体G2の記録再生特性の評価試験を行い、本発明媒体F2と従来媒体A1のエンベロップ特性を調べたところ、本発明媒体A2と同様に、本発明媒体F2は、従来媒体A1に比較して遥かにエンベロップがきれいであり、エンベロップ特性が非常に優れていることが分かった。この実験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行ったが、IDヘッドで記録した信号をMRヘッドで読み出す

実験も行ったところ、同様なエンベロップ特性の違いが見られた。このことは、本発明媒体G2の下地軟磁性膜であるCoCrPt-SiO<sub>2</sub>分散膜は磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、CoCrPt-SiO<sub>2</sub>分散膜を室温で成膜した膜を下地に持つ媒体の結果も同様なものになる。

【0067】本発明媒体G2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A1と対比して、図21に示した。図21は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示してある。再生出力が低下する従来媒体A1に対して、図21から分かるように、本発明媒体G2は5000eの磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体G2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行ったところ、全く同様な傾向が見られた。この結果を図22に示す。

【0068】次に、本発明媒体G2の記録磁化の経時変化を測定し、従来媒体A1と対比して、図23に示した。図23は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示してある。再生出力が低下する従来媒体A1に対して、図23から分かるように、本発明媒体G2では、このような再生出力の低下は全く見られなかった。本発明媒体F2に用いているCoCrPt-SiO<sub>2</sub>分散膜は磁壁構造をとらないために、従来媒体A1のような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたような理由によって、CoCrPt-SiO<sub>2</sub>分散膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。

【0069】以上のことより、本発明媒体G2を用いることによって記録再生時のエンベロップ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

#### 【0070】実施例9

分散膜中のCoCrPtの体積比を50%程度に設定し、CoCrPtターゲットとCターゲットを用いて、基板にバイアス電圧を印加しながら実施例1と同じ成膜条件で、同時にスパッタし、基板上に膜厚500nmのCoCrPt-C分散膜を下地軟磁性膜として成膜したこと除いて、実施例1と同様にして垂直磁気記録媒体を作製し、本発明媒体H2とした。

【0071】CoCrPt-C分散膜を観察したところ、明瞭な磁壁構造は観察されなかったし、試料に徐々に磁場を印加しながら観察しても、変化は見られなかった。これは、基板温度を室温にして成膜したCoCrPt-C分散膜についても同様であった。以上のことは、

CoCrPt-C分散膜の磁化過程は磁壁移動によらないことを示している。

【0072】次に、CoCrPt-C分散膜の保磁力を測定したところ、本発明媒体H2のCoCrPt-C分散膜の保磁力は0.1Oe、基板温度を室温にして成膜したCoCrPt-C分散膜の保磁力は3000Oeであった。

【0073】本発明媒体H2の記録再生特性の評価試験を行い、本発明媒体H2と従来媒体A1のエンベロップ特性を調べたところ、本発明媒体A2と同様に、本発明媒体H2は、従来媒体A1に比較して遥かにエンベロップがきれいであり、エンベロップ特性が非常に優れていることが分かった。この実験は単磁極ヘッドによって記録した信号をMRヘッドで読み出すことによって行なったが、IDヘッドで記録した信号をMRヘッドで読み出す実験も行なったところ、同様なエンベロップ特性の違いが見られた。このことは、本発明媒体H2の下地軟磁性膜であるCoCrPt-C分散膜は磁壁構造をとらないため、突発性の雑音の発生を根本的に解決できていることを示している。また、実施例1のところで述べたような理由によって、CoCrPt-C分散膜を室温で成膜した膜を下地に持つ媒体の結果も同様なものになる。

【0074】本発明媒体H2の外部浮遊磁界に対する記録磁化の安定性を測定し、従来媒体A1と対比して、図24に示した。図24は、磁場印加前の再生出力に対する磁場印加後の再生出力を百分率で示してある。再生出力が低下する従来媒体A1に対して、図24から分かるように、本発明媒体H2は5000Oeの磁場を印加しても減磁は見られず、外部浮遊磁界に対する記録信号の安定性は、本発明媒体H2の方が遥かに優れていることが分かった。同様の実験をIDヘッドで記録した信号をMRヘッドで読み出す方法によっても行なったところ、全く同様な傾向が見られた。この結果を図25に示す。また、実施例1のところで述べたような理由によって、CoCrPt-C分散膜を室温で成膜した膜を下地に持つ媒体の外部浮遊磁界に対する記録磁化の安定性の結果は同様なものになる。

【0075】次に、本発明媒体H2の記録磁化の経時変化を測定し、従来媒体A1と対比して、図26に示した。図26は、 $t = 1$ 秒の時の再生出力に対する一定時間経過後の再生出力を百分率で示してある。再生出力が低下する従来媒体A1に対して、図26から分かるように、本発明媒体H2では、従来媒体A1のような再生出力の低下は全く見られなかった。本発明媒体H2に用いているCoCrPt-C分散膜は磁壁構造をとらないために、従来媒体A1のような磁壁移動による減磁の問題を根本的に解決することができたと考えられる。また、実施例1のところで述べたような理由によって、CoCrPt-C分散膜を室温で成膜した膜を下地に持つ媒体の記録磁化の経時変化の結果は同様なものになる。

【0076】以上のことより、本発明媒体H2を用いることによって記録再生時のエンベロップ特性の向上並びに下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁あるいは消磁の防止を実現でき、高記録密度の実現が容易となる。

#### 【0077】実施例10

分散膜中のCoPtの体積比を50%程度に設定し、スパッタ法によりCoPtターゲットとSiO<sub>2</sub>ターゲットを用い、基板にバイアスを印加しながら、以下の成膜条件で、同時にスパッタして、膜厚500nmのCoPt-SiO<sub>2</sub>分散膜を下地軟磁性膜として2.5インチの基板上に成膜した。

##### 成膜条件

チャンバの初期真空度	: $5 \times 10^{-7}$ mTorr以下
投入電力	: 0.5 kw
アルゴンガス圧	: 4 mTorr
基板温度	: 600°C
成膜速度	: 3 nm/sec

【0078】Co<sub>65</sub>Cr<sub>35</sub>(at%)ターゲット及びCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>(at%)ターゲットを用いて、CoPt-SiO<sub>2</sub>分散膜の上に基板温度200°CでCo<sub>65</sub>Cr<sub>35</sub>膜をそれぞれ膜厚0、10、20、50、100及び120nmで成膜し、連続してその上にCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜を膜厚100nmで成膜した。そして、更にその上にC保護膜を10nm成膜し、Co<sub>65</sub>Cr<sub>35</sub>膜を100nmとした媒体を本発明媒体J2とし、Co<sub>65</sub>Cr<sub>35</sub>膜を0nmとした、すなわちCo<sub>65</sub>Cr<sub>35</sub>膜を設けていない媒体を従来媒体B1とした。

【0079】本発明媒体J2の特性を評価するために、表面平滑性、垂直配向性、保持力、記録再生特性等を以下の評価方法で測定した。同じ評価方法を実施例11以下の実施例にも適用した。本発明媒体J2のCo<sub>65</sub>Cr<sub>35</sub>膜の表面平滑性Raを磁気力顕微鏡(AFM)で測定し、図27に示す結果を得た。膜厚0nmの時の値は、すなわちCoPt-SiO<sub>2</sub>分散膜表面のRaの値である。図27から分かるように、Co<sub>65</sub>Cr<sub>35</sub>膜の膜厚が10~100nmまではRaが低減し、表面平滑性の改善効果があることが分かる。しかし、膜厚100nmを越えると表面平滑性は悪化する。

【0080】0~120nmの膜厚のCo<sub>65</sub>Cr<sub>35</sub>膜をCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の直下に持つCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性を調べるために、X線回折を用いて、h c p (002)ピークのロッキングカーブの半値幅を求め、図28に示す結果を得た。図28から分かるように、膜厚10~100nmまでは、ロッキングカーブの半値幅が低下し、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性が向上していることが分かる。CoPt-SiO<sub>2</sub>分散膜上のCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜は完全な垂直磁化膜ではなく、膜形成の初期段階における10nmから20nmの初期層が存在する。ところが、Co<sub>65</sub>Cr<sub>35</sub>膜とCo<sub>78</sub>

Cr<sub>19</sub>Ta<sub>3</sub>膜の結晶構造が非常に近いために、垂直磁化膜の膜形成の初期段階から垂直異方性の強い結晶配向性に優れた膜が形成される。しかし、膜厚100nmを越えるとロッキングカーブの半値幅は増大し、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性は悪化する。

【0081】以上のことから分かるように、中間層Co<sub>65</sub>Cr<sub>35</sub>膜は、CoPt-SiO<sub>2</sub>分散膜表面の平滑性の改善効果とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性の改善効果の双方を有する。

【0082】次に、0~120nmの膜厚のCo<sub>65</sub>Cr<sub>35</sub>膜をCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の直下に持つCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の磁気特性をカー効果測定装置で調べ、図29に示すようなメジャーリングの角形比を得た。図29から分かるように、Co<sub>65</sub>Cr<sub>35</sub>膜の膜厚が10~100nmまでは、膜厚の増加に伴って角形比が改善される。しかし、膜厚100nmを越えると角形比は低下する。

【0083】本発明媒体J2及び従来媒体B1について、ID/MR複合ヘッドを用いて記録再生特性の評価試験を行った。ここで、ヘッドの記録トラック幅は4μm、再生トラック幅は3μm、記録ギャップ長は0.4μm、再生ギャップ長は0.32μmである。評価は記録電流10mAop、センス電流12mA、周速度12.7m/sec、浮上量45nm、ノイズのバンド帯域45MHzの条件下で行った。図30は媒体ノイズの記録密度依存性を示す。これより、本発明媒体J2は、従来媒体B1に比較して全記録密度において媒体ノイズが小さく、ノイズ特性が非常に優れていることが分かる。つまり、Co<sub>65</sub>Cr<sub>35</sub>中間層を挿入することによってCoPt-SiO<sub>2</sub>分散膜表面の平滑性の改善とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性の改善が同時に達成され、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>垂直磁化膜の磁気特性の角形比を向上させて初期層の膜厚を低減させることが出来、低ノイズ化につながった。Co<sub>65</sub>Cr<sub>35</sub>中間層の膜厚が100nm以下の媒体でも同様な結果が得られる。

【0084】図31は媒体S/Nの記録密度依存性を示す。これより、本発明媒体J2は従来媒体B1に比較して全記録密度において媒体S/Nが2~5dB良好であり、高記録密度対応の磁気ディスク媒体として優れていることが分かる。すなわち、本発明媒体K2を用いることにより、高記録密度の実現が容易となる。

#### 【0085】実施例11

分散膜中のCoCrPtの体積比を50%程度に設定し、CoCrPtターゲットとSiO<sub>2</sub>ターゲットを用いたことを除いて、実施例10と同じ成膜条件で膜厚500nmのCoCrPt-SiO<sub>2</sub>分散膜を下地軟磁性膜として基板上に成膜した。次いで、Tiターゲット及びCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>(at%)ターゲットを用いて、CoCrPt-SiO<sub>2</sub>分散膜の上に基板温度200℃でTi膜を膜厚0、10、20、50、100及び120nmで成膜し、連続してTi膜の上にCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>

膜を膜厚100nmで成膜した。そして、更にCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の上にC保護膜を10nm成膜し、Ti膜を100nmとした媒体を本発明媒体K2とし、Ti膜を0nmとした、すなわちTi膜を設けていない媒体を従来媒体C1とした。

【0086】Ti膜の表面平滑性Raを測定し、図32に示す結果を得た。膜厚0nmの時の値はすなわちCoCrPt-SiO<sub>2</sub>分散膜表面のRaの値である。図32から分かるように、Ti膜の膜厚が10~100nmまではRaが低減し、表面平滑性の改善効果があることが分かる。しかし、膜厚100nmを越えると表面平滑性は悪化する。

【0087】0~120nmの膜厚のTi膜をCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の直下に持つCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性を調べ、図33に示す結果を得た。図33から分かるように、膜厚10~100nmまではロッキングカーブの半値幅が低下し、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性が向上していることが分かる。CoCrPt-SiO<sub>2</sub>分散膜上のCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜は完全な垂直磁化膜ではなく、膜形成の初期段階における10nmから20nmの初期層が存在する。ところが、Ti膜とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜は格子整合性が良いために、垂直磁化膜の膜形成の初期段階から垂直異方性の強い結晶配向性に優れた膜が形成される。しかし、膜厚100nmを越えるとロッキングカーブの半値幅は増大し、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性は悪化する。以上のことから分かるように、中間層Ti膜は、CoCrPt-SiO<sub>2</sub>分散膜表面の平滑性の改善効果とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性の改善効果の双方を有する。

【0088】次に、0~120nmの膜厚のTi膜をCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の直下に持つCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の磁気特性を調べ、図34に示す結果を得た。図34から分かるように、Ti膜の膜厚が10~100nmまでは、膜厚の増加に伴って角形比が改善される。しかし、膜厚100nmを越えると角形比は低下する。

【0089】本発明媒体K2及び従来媒体C1の記録再生特性の評価試験を行い、図35に示す媒体ノイズの記録密度依存性の結果を得た。本発明媒体K2は、従来媒体C1に比較して、全記録密度において媒体ノイズが小さく、ノイズ特性が非常に優れていることが分かる。つまり、Ti中間層を挿入することによってCoCrPt-SiO<sub>2</sub>分散膜表面の平滑性の改善とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性の改善が同時に達成され、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>垂直磁化膜の磁気特性の角形比を向上させて初期層の膜厚を低減させることが出来、低ノイズ化につながった。以上のことから、Ti中間層の膜厚が100nm以下の媒体でも同様な結果が得られる。

【0090】図36は媒体S/Nの記録密度依存性を示す。これより、本発明媒体K2は従来媒体C1に比較して全記録密度において媒体S/Nが1~2dB良好であ

り、高記録密度対応の磁気ディスク媒体として優れていることが分かる。すなわち、本発明媒体K2を用いることにより、高記録密度の実現が容易となる。

#### 【0091】実施例12

分散膜中のCoCrPtの体積比を50%程度に設定し、CoCrPtターゲットとCターゲットを用いたことを除いて、実施例10と同じ成膜条件で膜厚500nmのCoCrPt-C分散膜を下地軟磁性膜として基板上に成膜した。次いで、Cr<sub>20</sub>Ti<sub>80</sub>ターゲットとCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>(at%)ターゲットを用いて、CoCrPt-C分散膜の上に基板温度200°CでCr<sub>20</sub>Ti<sub>80</sub>膜を膜厚0、10、20、50、100及び120nmで成膜し、更に連続してCr<sub>20</sub>Ti<sub>80</sub>膜の上にCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜を膜厚100nmで成膜した。次いで、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の上にC保護膜を10nm成膜し、Cr<sub>20</sub>Ti<sub>80</sub>膜を100nmとした媒体を本発明媒体L2とし、Cr<sub>20</sub>Ti<sub>80</sub>膜を0nmとした、すなわちTi膜を設けていない媒体を従来媒体D1とした。

【0092】Cr<sub>20</sub>Ti<sub>80</sub>膜の表面平滑性Raを測定し、図37に示す結果を得た。膜厚0nmの時の値はすなわちCoCrPt-C分散膜表面のRaの値である。図37から分かるように、Cr<sub>20</sub>Ti<sub>80</sub>膜の膜厚が10～100nmまではRaが低減し、表面平滑性の改善効果があることが分かる。しかし、膜厚100nmを越えると表面平滑性は悪化する。

【0093】0～120nmの膜厚のCr<sub>20</sub>Ti<sub>80</sub>膜をCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の直下に持つCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性を調べ、図38に示す結果を得た。図38から分かるように、膜厚10～100nmまではロッキングカーブの半値幅が低下し、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性が向上していることが分かる。CoCrPt-C分散膜上のCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜は完全な垂直磁化膜ではなく、膜形成の初期段階における10nmから20nmの初期層が存在する。ところが、Cr<sub>20</sub>Ti<sub>80</sub>膜とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜は格子整合性が良いために、垂直磁化膜の膜形成の初期段階から垂直異方性の強い結晶配向性に優れた膜が形成される。しかし、膜厚100nmを越えるとロッキングカーブの半値幅は増大し、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性は悪化する。以上のことから分かるように、中間層Cr<sub>20</sub>Ti<sub>80</sub>膜は、CoCrPt-C分散膜表面の平滑性の改善効果とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性の改善効果の双方を有する。

【0094】次に、0～120nmの膜厚のCr<sub>20</sub>Ti<sub>80</sub>膜をCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の直下に持つCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の磁気特性を調べ、図39に示す結果を得た。図39から分かるように、Cr<sub>20</sub>Ti<sub>80</sub>膜の膜厚が10～100nmまでは、膜厚の増加に伴って角形比が改善される。しかし、膜厚100nmを越えると角形比は低下する。

【0095】本発明媒体L2及び従来媒体D1の記録再

生特性の評価試験を行い、図40に示す媒体ノイズの記録密度依存性の結果を得た。これより、本発明媒体L2は、従来媒体D1に比較して全記録密度において媒体ノイズが小さく、ノイズ特性が非常に優れていることが分かる。つまり、Cr<sub>20</sub>Ti<sub>80</sub>中間層を挿入することによってCoCrPt-C分散膜表面の平滑性の改善とCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜の垂直配向性の改善が同時に達成され、Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>垂直磁化膜の磁気特性の角形比を向上させて初期層の膜厚を低減させることが出来、低ノイズ化につながった。また、Cr<sub>20</sub>Ti<sub>80</sub>中間層の膜厚が100nm以下の媒体でも同様な結果が得られる。

【0096】図41は媒体S/Nの記録密度依存性を示す。これより、本発明媒体L2は従来媒体D1に比較して全記録密度において媒体S/Nが1～4dB良好であり、高記録密度対応の磁気ディスク媒体として優れていることが分かる。すなわち、本発明媒体L2を用いることにより、高記録密度の実現が容易となる。

#### 【0097】実施例13

2.5インチの基板上にスパッタ法により基板温度600°CでCrターゲットを用いてCr膜を膜厚0、100、200、300、400、及び500nmで成膜した。次いで、実施例10と同様にして、Cr膜上に膜厚500nmのCoPt-SiO<sub>2</sub>分散膜、膜厚100nmのCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜、及び膜厚10nmのC保護膜を成膜し、500nm膜厚のCr膜を挿入した媒体を本発明媒体M2とし、Cr膜を挿入せず、CoPt-SiO<sub>2</sub>分散膜及びCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜を成膜した媒体を従来媒体E1とした。

【0098】次に、Cr下地を持つCoPt-SiO<sub>2</sub>分散膜と持たないCoPt-SiO<sub>2</sub>分散膜の保磁力を試料振動型磁力計(VSM)を用いて測定し、図42に示す結果を得た。図42から分かるように、Cr下地の膜厚の増加にともなってCoPt-SiO<sub>2</sub>分散膜の保磁力は増加する。

【0099】実施例10と同じ再生条件で、本発明媒体M2及び従来媒体E1の記録再生特性の評価試験を行い、図43に示す媒体ノイズの記録密度依存性を得た。本発明媒体M2、従来媒体E1ともに孤立波の出力値(この場合、記録密度10kFRPIの時の出力値)で規格化してある。これより、本発明媒体M2は、従来媒体E1に比較して記録密度の増大に伴う出力の減衰が遅い。言い換えれば本発明媒体M2の方が従来媒体E1よりも高記録密度まで高い出力を得ることができる。CoPt-SiO<sub>2</sub>分散膜の下にCr下地を挿入することによって保磁力が増大し、出力の記録密度依存性の向上が達成された。

【0100】図44は、記録密度400kFRPIでの媒体S/Nの値を示す。これより、本発明媒体M2は従来媒体E1に比較して高記録密度においても媒体S/Nが約2dB良好であり、高記録密度対応の磁気ディスク媒

体として優れていることが分かる。すなわち、本発明媒体M2を用いることにより、高記録密度の実現が容易となる。

#### 【0101】実施例14

実施例13のCr膜に代えて、Vターゲットを用いてV膜をそれぞれ膜厚0、100、200、300、400及び500nmで成膜し、次いで実施例11と同様にし、垂直磁気記録媒体を作製し、500nm膜厚のV膜を挿入した媒体を本発明媒体N2とし、V膜を挿入せず、CoCrPt-SiO<sub>2</sub>分散膜及びCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜を成膜した媒体を従来媒体F1とした。

【0102】次に、実施例13と同様にし、V下地を持つCoCrPt-SiO<sub>2</sub>分散膜と持たないCoCrPt-SiO<sub>2</sub>分散膜の保磁力を測定し、図45に示す結果を得た。図45から分かるように、V下地の膜厚の増加にともなってCoCrPt-SiO<sub>2</sub>分散膜の保磁力は増加する。

【0103】実施例13と同様にし、本発明媒体N2及び従来媒体F1の記録再生特性の評価試験を行い、図46に示す媒体ノイズの記録密度依存性を得た。本発明媒体N2、従来媒体F1ともに孤立波の出力値（この場合、記録密度10kFRPIの時の出力値）で規格化してある。これより、本発明媒体N2は、従来媒体F1に比較して記録密度の増大に伴う出力の減衰が遅い。言い換えれば本発明媒体N2の方が従来媒体F1よりも高記録密度まで高い出力を得ることができる。CoCrPt-SiO<sub>2</sub>分散膜の下にV下地を挿入することによって保磁力が増大し、出力の記録密度依存性の向上が達成された。

【0104】図47は記録密度400kFRPIでの媒体S/Nの値を示す。これより、本発明媒体N2は従来媒体F1に比較して高記録密度においても媒体S/Nが約2dB良好であり、高記録密度対応の磁気ディスク媒体として優れていることが分かる。すなわち、本発明媒体M2を用いることにより、高記録密度の実現が容易となる。

#### 【0105】実施例15

実施例13のCr膜に代えて、Cuターゲットを用いてCu膜をそれぞれ膜厚0、100、200、300、400及び500nmで成膜し、次いで実施例12と同様にし、垂直磁気記録媒体を作製し、500nm膜厚のCu膜を挿入した媒体を本発明媒体P2とし、Cu膜を挿入せずに、CoCrPt-C分散膜及びCo<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub>膜を成膜した媒体を従来媒体G1とした。

【0106】次に、実施例13と同様にし、Cu下地を持つCoCrPt-C分散膜と持たないCoCrPt-C分散膜の保磁力を調べ、図48に示す結果を得た。図48から分かるように、Cu下地の膜厚の増加にともなってCoCrPt-C分散膜の保磁力は増加する。

【0107】実施例13と同様にし、本発明媒体P2

及び従来媒体G1の記録再生特性の評価試験を行い、図49に示す媒体ノイズの記録密度依存性の結果を得た。本発明媒体P2、従来媒体G1ともに孤立波の出力値（この場合、記録密度10kFRPIの時の出力値）で規格化してある。これより、本発明媒体P2は、従来媒体G1に比較して記録密度の増大に伴う出力の減衰が遅い。言い換えれば本発明媒体P2の方が従来媒体G1よりも高記録密度まで高い出力を得ることができる。CoCrPt-C分散膜の下にCu下地を挿入することによって保磁力が増大し、出力の記録密度依存性の向上が達成された。

【0108】図50は記録密度400kFRPIでの媒体S/Nの値を示す。これより、本発明媒体P2は従来媒体G1に比較して高記録密度においても媒体S/Nが約2dB良好であり、高記録密度対応の磁気ディスク媒体として優れていることが分かる。すなわち、本発明媒体M2を用いることにより、高記録密度の実現が容易となる。

#### 【0109】

【発明の効果】本発明によれば、非磁壁構造の下地軟磁性膜を垂直磁化膜の下に設けることにより、記録再生時のエンベロップ特性を向上させ、かつ下地軟磁性膜の磁壁の移動に由来する突発性の雑音や記録磁化の減磁又は消磁現象が発生しない垂直磁気記録媒体を実現している。これにより、従来、垂直磁気記録媒体の致命的な欠陥であった記録磁化の減磁又は消磁現象の発生を根本的に防止することができ、記録再生特性に優れた垂直磁気記録媒体を実現している。

【0110】請求項6及び7に記載の垂直磁気記録媒体によれば、下地軟磁性膜として用いるグラニューラ薄膜と垂直磁化膜の間に接合層を挿入することにより、下地軟磁性膜の表面平滑性の向上と垂直磁化膜の垂直配向性の向上を同時に図ることができる。この効果により、垂直磁化膜の磁気特性の角形比が改善され、低媒体ノイズ化を図ることができ、記録再生特性にすぐれた垂直磁気記録媒体を実現している。

【0111】請求項8に記載の垂直磁気記録媒体によれば、下地軟磁性膜として用いるグラニューラ薄膜と基板の間にCr膜、V膜及びCu膜のいずれかを挿入することにより、Cr膜、V膜、Cu膜を挿入しない場合に比べて母材中に分散させた粒子の独立を促進させることができ、保磁力の向上を図ることができる。この効果により、再生出力の記録密度依存性の向上を図ることができ、記録再生特性にすぐれた垂直磁気記録媒体を実現している。

#### 【図面の簡単な説明】

【図1】図1(a)及び(b)は、それぞれ、本発明に関わる垂直磁気記録媒体の実施形態例、及び実施例1の垂直磁気記録媒体の模式的基板断面図である。

【図2】実施例1の垂直磁気記録媒体のエンベロップ特



【図 4 7】実施例 1 4 の垂直磁気記録媒体の媒体 S/N の値を示す図表である。

【図 4 8】実施例 1 4 の垂直磁気記録媒体の軟磁性膜の地下層の膜厚と保磁力の関係を示す図表である。

【図 4 9】実施例 1 4 の垂直磁気記録媒体の出力の記録密度依存性を示すグラフである。

【図 5 0】実施例 1 4 の垂直磁気記録媒体の媒体 S/N の値を示す図表である。

【図 5 1】従来の垂直磁気記録媒体を示す概略断面図である。

【図 5 2】実施例 3 の垂直磁気記録媒体の外部磁場と磁場印加前後の再生出力の比を示すグラフである。

【図 5 3】実施例 3 の垂直磁気記録媒体の外部磁場と磁場印加前後の再生出力の比を示す別のグラフである。

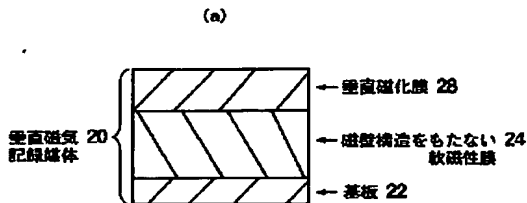
【図 5 4】実施例 3 の垂直磁気記録媒体の外部磁場印加

後の経過時間と一定時間経過前後の再生出力の比を示すグラフである。

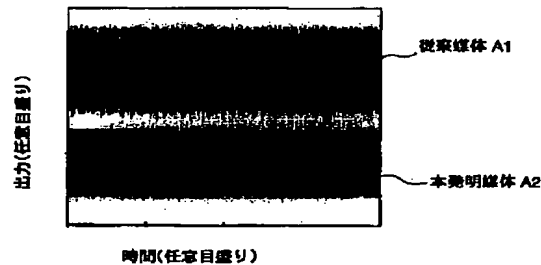
【符号の説明】

- 1 0 垂直磁気記録媒体
- 1 2 基板
- 1 6 FeSiAl 軟磁性膜
- 1 8  $\text{Co}_{78}\text{Cr}_{19}\text{Ta}_3$  垂直磁化膜
- 2 0 垂直磁気記録媒体
- 2 2 基板
- 2 4 磁壁構造をもたない軟磁性膜
- 2 8 垂直磁化膜
- 5 0 垂直磁気記録媒体
- 5 2 軟磁性裏打ち層
- 5 4 垂直磁化膜
- 5 6 基板

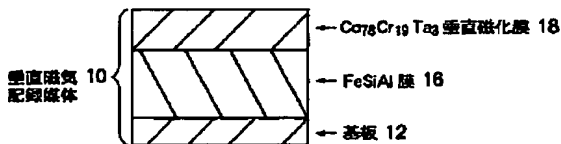
【図 1】



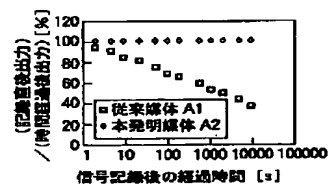
【図 2】



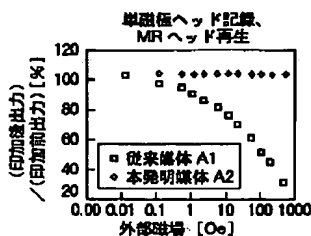
(b)



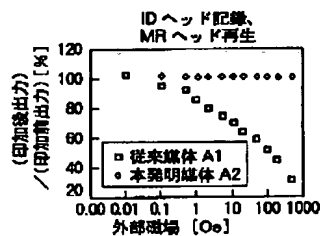
【図 5】



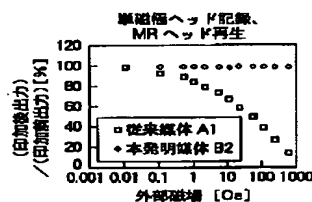
【図 3】



【図 4】



【図 6】



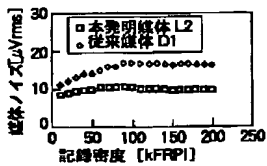
【図 38】

Cr <sub>20</sub> Ti <sub>80</sub> 膜厚 [nm]	0	10	20	80	100	120
Co <sub>10</sub> Cr <sub>10</sub> Ti <sub>80</sub> 膜厚 [nm]	0	0	0	0	0	0
角形比	8.5	1.2	1.8	1.7	1.5	8.8

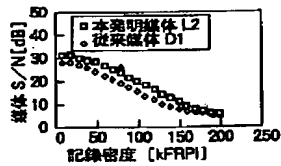
【図 39】

Cr <sub>20</sub> Ti <sub>80</sub> 膜厚 [nm]	0	10	20	80	100	120
角形比	0.69	0.97	0.95	0.98	0.98	0.82

【図 40】



【図 41】

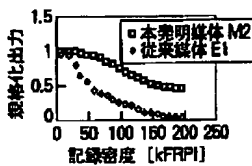


【図 42】

Cr 膜厚 [nm]	0	100	200	300	400	500
He[Oe]	0.1	200	280	350	410	600

【図 47】

【図 43】



【図 44】

従来媒体 E1 の 400kFRPI での 媒体 S/N [dB]	29.7
本発明媒体 M2 の 400kFRPI での 媒体 S/N [dB]	32.2

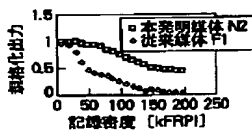
【図 45】

V 膜厚 [nm]	0	100	200	300	400	500
He[Oe]	0.1	220	310	360	420	610

【図 49】

従来媒体 F1 の 400kFRPI での 媒体 S/N [dB]	28.8
本発明媒体 M2 の 400kFRPI での 媒体 S/N [dB]	31.9

【図 46】

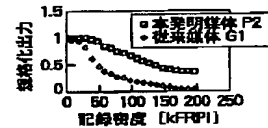


【図 48】

Cu 膜厚 [nm]	0	100	200	300	400	500
He[Oe]	0.1	180	310	340	450	600

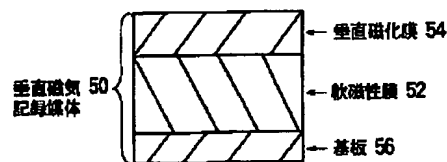
【図 51】

【図 52】

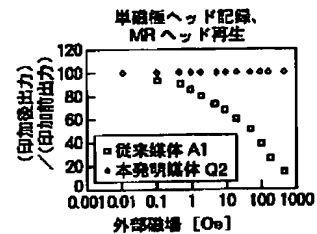


【図 50】

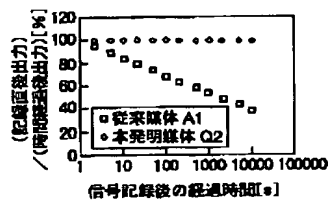
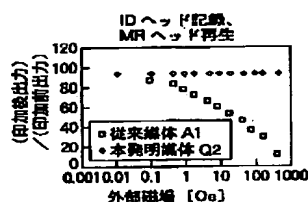
従来媒体 G1 の 400kFRPI での 媒体 S/N [dB]	29.5
本発明媒体 P2 の 400kFRPI での 媒体 S/N [dB]	31.9



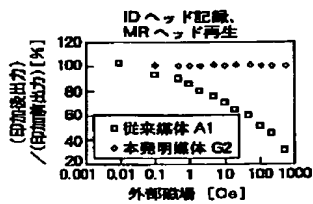
【図 54】



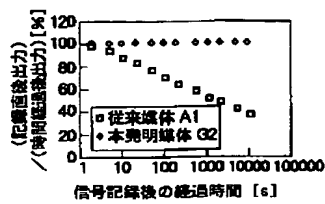
【図 53】



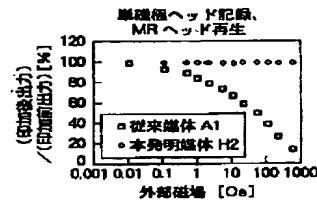
【図22】



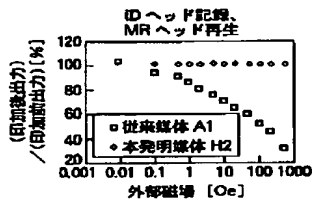
【図23】



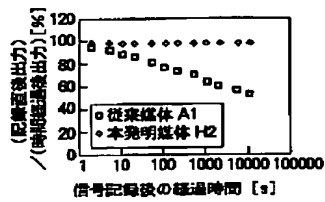
【図24】



【図25】



【図26】



【図27】

C <sub>65</sub> Cr <sub>35</sub> 膜厚 [nm]	0	0	20	50	100	120
Ra [nm]	5.1	0.52	0.48	0.60	0.55	4.5

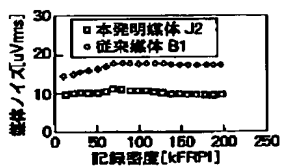
【図28】

C <sub>65</sub> Cr <sub>35</sub> 膜厚 [nm]	0	10	20	50	100	120
C <sub>70</sub> Cr <sub>19</sub> Ta <sub>11</sub> 膜の $\Delta\theta_{50}$ [°]	8.7	1.5	1.9	2.1	1.5	5.6

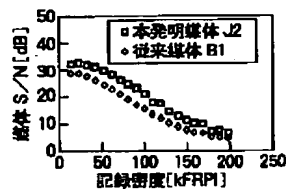
【図29】

C <sub>65</sub> Cr <sub>35</sub> 膜厚 [nm]	0	0	20	50	100	120
角形比	0.61	0.96	0.96	0.99	0.98	0.65

【図30】



【図31】



【図32】

Ti 膜厚 [nm]	0	10	20	50	100	120
Ra [nm]	8.5	0.55	0.48	0.56	0.52	5.3

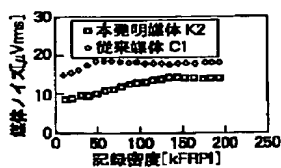
【図33】

Ti 膜厚 [nm]	0	10	20	50	100	120
C <sub>70</sub> Cr <sub>19</sub> Ta <sub>11</sub> 膜の $\Delta\theta_{50}$ [°]	10.2	2.2	2.2	1.6	2.1	8.8

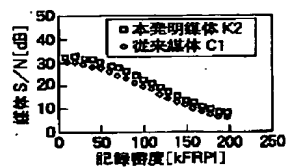
【図34】

Ti 膜厚 [nm]	0	10	20	50	100	120
角形比	0.65	0.95	0.95	0.98	0.95	0.67

【図35】



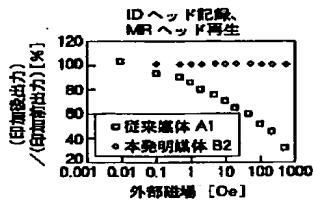
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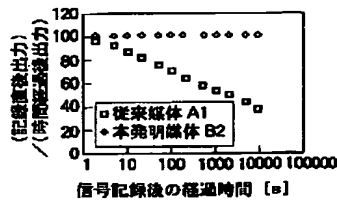
【図37】

Cr <sub>20</sub> Ti <sub>80</sub> 膜厚 [nm]	0	10	20	50	100	120
Ra [nm]	4.9	0.52	0.47	0.56	0.52	3.9

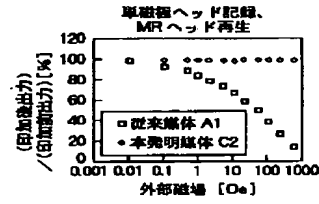
【図7】



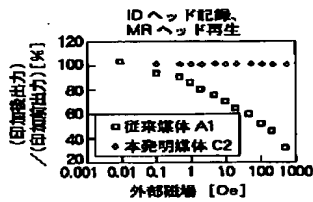
【図8】



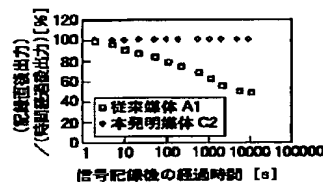
【図9】



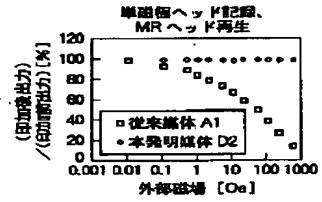
【図10】



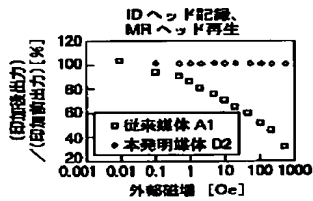
【図11】



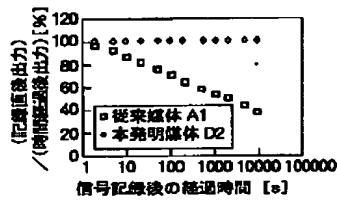
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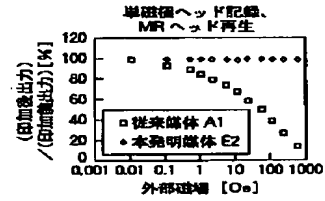
【図13】



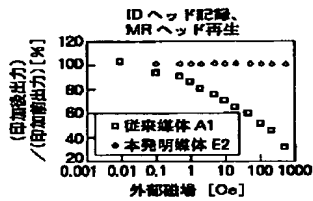
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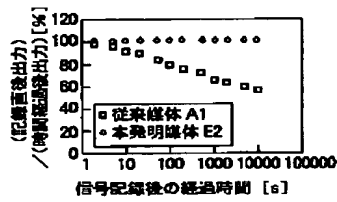
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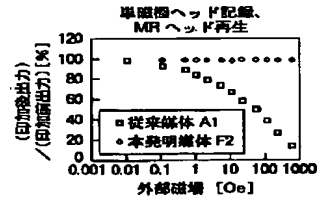
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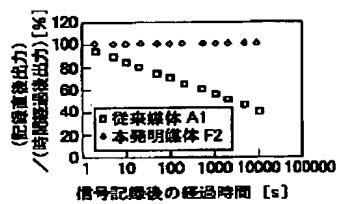
【図17】



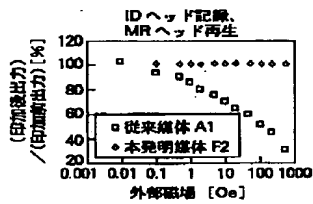
【図18】



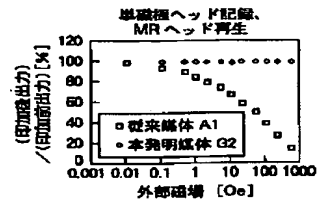
【図20】



【図19】



【図21】



## \* NOTICES \*

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the good vertical-magnetic-recording medium of record reproducing characteristics still in detail about the vertical-magnetic-recording medium used as a magnetic disk etc.

[0002]

[Description of the Prior Art] progress of recent years, a personal computer, or a workstation -- following -- a hard disk drive -- large-capacity-izing -- and since it miniaturizes, the magnetic disk needs the further high side recording density-ization. However, if the longitudinal recording method which has spread widely now tends to realize high side recording density, the problem magnetization / record / accompanying detailed-izing of a record bit ] of heat fluctuation and the problem of a raise in coercive force exceeding the record capacity of a recording head will occur. Then, solving these problems, as a means to increase field recording density sharply, vertical magnetic recording is examined and the perpendicular two-layer medium which consists of a soft-magnetism film of high permeability and perpendicular magnetic anisotropy films of a high perpendicular anisotropy as one of the vertical-magnetic-recording media which realizes this is proposed.

[0003] Below, with reference to drawing 51, the composition of the conventional perpendicular two-layer medium is explained. Drawing 51 is the typical substrate cross section of the conventional vertical-magnetic-recording medium. The soft-magnetism backing layer 52 and perpendicular magnetic anisotropy films 54 are formed on a substrate 56 one by one, and the conventional vertical-magnetic-recording medium 50 becomes, as shown in drawing 51. For example, the CoCr system alloy is used for the soft-magnetism backing layer 52 at a NiFe film and perpendicular magnetic anisotropy films 54, respectively (the Magnetics Society of Japan, Vol.8, No.1, 1984, p17).

[0004]

[Problem(s) to be Solved by the Invention] However, there was a problem which is explained below in the conventional vertical-magnetic-recording medium as shown in drawing 51. Since the ground soft-magnetism film 52 has magnetic-domain-wall (magnetic domain) structure divided roughly into a BUROHHO line magnetic domain wall and a nail magnetic domain wall, the first problem is the noise (spike noise) of outbreak nature occurring in the case of record reproduction of a vertical-magnetic-recording medium, degrading an envelope property, and checking reproductive fidelity. The noise of such outbreak nature is generated when a head passes through the upper part of the magnetic domain wall produced on the ground soft-magnetism film 52. The second problem is the instability of the record magnetization by the external suspension magnetic field. Since the ground soft-magnetism film 52 has magnetic-domain-wall structure, the magnetic domain wall in the ground soft-magnetism layer 52 moves easily by the external suspension magnetic field. If movement of such a magnetic domain wall takes place in the field in the ground soft-magnetism layer 52 corresponding to the main pole of the perpendicular magnetic head, demagnetization of the magnetization recorded on the perpendicular magnetic anisotropy films 54 which function as a vertical recording layer, or a demagnetization phenomenon will occur. The suspension magnetic field from such the outside is generated from the motor side for the disk rotation in the magnetic disk drive arranged in the magnetic disk and the position which approached, the motor side used for head positioning. Since these magnetic fields may induce magnetic-domain-wall movement of a ground soft-magnetism film and may demagnetize or demagnetize record magnetization when it concentrates at the nose of cam of the main pole of the perpendicular magnetic head although it is very feeble, they serve as a defect fatal as an information storage device.

[0005] Then, the purpose of this invention is to offer the vertical-magnetic-recording medium of new composition so that demagnetization or the demagnetization phenomenon of the noise of the outbreak nature which the envelope property at the time of record reproduction is excellent in, and originates in movement of the magnetic domain wall of a ground soft-magnetism film, and record magnetization may not arise.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, in the vertical-magnetic-recording medium which has at least a substrate, the soft-magnetism film prepared on the substrate, and the perpendicular magnetic anisotropy films prepared on the soft-magnetism film, a soft-magnetism film is formed as non-magnetic-domain-wall structure, and the vertical-magnetic-recording medium concerning this invention is characterized by the coercive force being 300 or less Oes. By this invention, the soft-magnetism film of non-magnetic-domain-wall structure means a soft-magnetism film without magnetic-domain-wall structure.

[0007] In order to form the soft-magnetism film of non-magnetic-domain-wall structure, a soft-magnetism film is formed with

FeSiAl or a FeSiAl system alloy. Moreover, you may form a soft-magnetism film with FeTaN or a FeTaN system alloy. Furthermore, you may form the soft-magnetism film of a granular thin film. In that case, the granular thin film is formed by either of the matrix elements of the matrix which constituted as a line the material of the particle which SiO<sub>2</sub> or C is used [ particle ] as the base material of a granular thin film, and it considers [ particle ] as the material of the particle which distributes either Co, CoPt and CoCrPt in a base material, and makes a train and mother existence distribute a base material.

[0008] Since the granular thin film is distributing other matter in a base material, generally surface smooth nature is seldom excellent. Then, the junction layer of 100nm or less of thickness is made to intervene between a soft-magnetism film and perpendicular magnetic anisotropy films preferably by the vertical-magnetic-recording medium of this invention. By this, the improvement in the surface smooth nature of a soft-magnetism film and improvement in the perpendicular stacking tendency of perpendicular magnetic anisotropy films can be attained simultaneously, and the remanence ratio of the magnetic properties of perpendicular magnetic anisotropy films can be improved, low medium noise-ization can be attained, and it can consider as the good medium of record reproducing characteristics. It is desirable to form a junction layer by either Co<sub>1-X</sub>Cr<sub>x</sub> (0.25≤x≤0.60), Ti and CrTi in that case.

[0009] Either Cr film of 500nm or less of thickness, V film and Cu film are made to intervene between a granular thin film and a substrate suitably by the vertical-magnetic-recording medium which uses a granular thin film as a soft-magnetism film. Since independent-ization of the particle distributed in the base material can be promoted by this compared with the case where Cr film, V film, or Cu film is not inserted, coercive force increases, improvement in the recording density dependency of a reproduction output can be aimed at, and it is possible to consider as the good medium of record reproducing characteristics. Moreover, a granular thin film is suitably made into non-magnetic-domain-wall structure.

[0010] Although magnetic-domain-wall structure is divided roughly into the BUROHHO line magnetic domain wall and the nail magnetic domain wall, the vertical-magnetic-recording medium concerning this invention equips the bottom of perpendicular magnetic anisotropy films with the soft-magnetism film which does not have such magnetic-domain-wall structure by specifying the membrane formation material of a soft-magnetism film. Therefore, many problems which had been generated to the conventional vertical-magnetic-recording medium using the soft-magnetism film which has magnetic-domain-wall structure, Namely, the noise of the outbreak nature generated when it passes through the upper part of the magnetic domain wall which the perpendicular magnetic head has produced on the soft-magnetism film (spike noise), Or by the suspension magnetic field generated from the motor side for disk rotation, the motor side for head positioning, etc., the magnetic domain wall of a soft-magnetism film can move, the problem of demagnetizing or demagnetizing record magnetization can be solved fundamentally, and the medium of a low noise with a good envelope property can be realized.

[0011]

[Embodiments of the Invention] The example of an operation form is given to below, and the form of operation of this invention is explained to it concretely and in detail with reference to an accompanying drawing.

The example of the example book operation form of an operation form is one example of the operation form of the vertical-magnetic-recording medium concerning this invention, and drawing 1 (a) is the typical substrate cross section showing the composition of the vertical-magnetic-recording medium of this example of an operation form. The vertical-magnetic-recording medium 20 of this example of an operation form is equipped with perpendicular magnetic anisotropy films, a substrate 22, and the ground soft-magnetism film 24 of the non-magnetic-domain-wall structure formed one by one on the substrate 22, i.e., the ground soft-magnetism film which does not have magnetic-domain-wall structure, 28, or the becoming laminated structure as shown in drawing 1 (a). a FeSiAl film or a FeSiAl system alloy film, a FeTaN film, or a FeTaN system alloy film -- further SiO<sub>2</sub> or C as a material of the particle distributed in the base material as a base material Co, The ground soft-magnetism film which does not have magnetic-domain-wall structure can be formed by adopting CoPt or CoCrPt and using the granular thin film which formed the material of the particle which makes a train and mother existence distribute a base material by either of the matrix elements of the matrix made into the line.

[0012] By the above composition, the vertical-magnetic-recording medium 20 concerning this invention can solve fundamentally many problems which are generated when a ground soft-magnetism film takes magnetic-domain-wall structure and which were mentioned above.

[0013]

[Example] An example is given to below and the form of operation of this invention is explained to it concretely and in detail with reference to an accompanying drawing.

Example 1 this example is one of the examples of the vertical-magnetic-recording medium concerning this invention. Drawing 1 (b) is the substrate cross section showing the composition of the vertical-magnetic-recording medium of this example of an operation form. the ground soft-magnetism film 16 with which the vertical-magnetic-recording medium 10 of this example consists of a FeSiAl film of 500nm of thickness formed on 2.5 inches a substrate 12 and a substrate 12, and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film (at%) formed on the ground soft-magnetism film 16 from -- it is formed as a laminated structure which has the becoming perpendicular magnetic anisotropy films 18 and C protective coat (not shown)

[0014] Below, how to produce the vertical-magnetic-recording medium 10 of this example is explained. First, the ground soft-magnetism film 16 which consists of a FeSiAl film of 500nm of thickness on the 2.5 inches substrate 12 on the following membrane formation conditions by the spatter was formed using the 6 inches FeSiAl target.

Initial degree of vacuum of a membrane formation condition chamber : 5×10<sup>-7</sup> or less mTorr substrate temperature :

600-degree-C injection power : 0.5kw argon gas pressure : 4mTorr membrane formation speed : 3 nm/sec [0015] Subsequently, the perpendicular magnetic anisotropy films 18 which use Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> (at%) target and consist of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film of

100nm of thickness at the substrate temperature of 200 degrees C on the ground soft-magnetism film 16 which consists of a FeSiAl film were formed. Furthermore, C protective coat of 10nm of thickness was formed on Co78Cr19Ta3 film 18, and the obtained vertical-magnetic-recording medium was used as this invention medium A2. Moreover, the FeSiAl film which formed membranes by carrying out to the room temperature also produced substrate temperature to comparison of coercive force. [0016] On the other hand, apart from this invention medium A2, the medium which formed the ground soft-magnetism film which consists of a NiFe film like an example 1, and Co78Cr19Ta3 (at%) film was conventionally used as the medium A1 by using a NiFe target instead of a FeSiAl film.

[0017] In order to evaluate the vertical-magnetic-recording medium A2 concerning this invention, observation of magnetic-domain-wall structure, measurement of coercive force, measurement of record reproducing characteristics, etc. were performed as follows. The same evaluation method also as a two or less-example example was applied. In order to investigate the magnetic-domain-wall structure of the FeSiAl film 16 of this invention medium A2, magnetic-domain-wall structure was observed by the powder figure method as follows. First, the very small blemish was given to the front face of the FeSiAl film which formed membranes at the substrate temperature of 600 degrees C, and after making it easy to be visible in magnetic-domain-wall structure, BITTA-liquid (magnetic colloid) was applied on it. And although the sample was set to the electromagnet for magnetic-domain-wall observation and magnetic-domain-wall structure was observed with the metaloscope, clear magnetic-domain-wall structure was not observed. Next, change was not seen when observed impressing a magnetic field to a sample gradually. This was the same also about the FeSiAl film which made substrate temperature the room temperature and formed membranes. Subsequently, similarly, when the NiFe film of a medium A1 was observed conventionally, clear magnetic-domain-wall structure was observed. And when observed impressing a magnetic field to a sample gradually, the situation of movement of a magnetic domain wall was observed clearly. It is shown to the above thing being a magnetization process according [ the magnetization process of a NiFe film ] to magnetic-domain-wall movement that the magnetization process of a FeSiAl film is not based on magnetic-domain-wall movement.

[0018] Next, in order to investigate the coercive force of a FeSiAl film and a NiFe film, the sample oscillatory-type magnetometer (VSM) was used and coercive force was measured. Consequently, the coercive force of the FeSiAl film which the coercive force of the FeSiAl film which formed membranes at the substrate temperature of 600 degrees C, and a NiFe film made 0.1Oe(s) and substrate temperature the room temperature, respectively, and formed membranes was 300Oe(s).

[0019] The evaluation examination of record reproduction was performed about the medium A1 this invention medium A2 and conventionally using the single magnetic pole head and the ID/MR combined head. here -- ID/MR combined-head recording track width of face -- 4 micrometers regenerative-track width of face -- 3 micrometers record gap length -- 0.4 micrometers and reproduction gap length -- 0.32 micrometers it was . moreover, the width of recording track of a single magnetic pole head -- 10 micrometers main pole thickness -- 0.4 micrometers it was . The evaluation examination was performed under conditions of record current 10mAop, 12mA of sense current, peripheral-velocity 12.7 m/sec, 45nm of flying heights, and 45MHz of band bands of a noise. In addition, the experiment followed in both the case where the signal recorded by the single magnetic pole head is read by the MR head, and the case of reading the signal which recorded with ID head by the MR head. Drawing 2 shows a medium A1 envelope property this invention medium A2 and conventionally. As shown in drawing 2 , this invention medium A2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this evaluation examination was performed by reading the signal recorded by the single magnetic pole head by the MR head, when the evaluation examination which reads the signal recorded with ID head by the MR head was also performed, the difference in the same envelope property was seen.

[0020] In order that the ground soft-magnetism film FeSiAl of this invention medium A2 may not take magnetic-domain-wall structure to the noise of the outbreak nature accompanying movement of a magnetic domain wall being conventionally seen, as for this in order that the ground soft-magnetism film NiFe of a medium A1 may take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the FeSiAl film at the room temperature in a ground will also become the same. It is because magnetic-domain-wall structure cannot be originally made easily if coercive force of the magnetic substance is large, and the coercive force of the FeSiAl film which formed membranes at the room temperature in this case is farther [ than the coercive force of the FeSiAl film which formed membranes at the substrate temperature of 600 degrees C ] large, and it is because it is in the state where magnetic-domain-wall structure cannot be made much more easily.

[0021] Next, the stability of record magnetization of as opposed to an external suspension magnetic field as follows was evaluated about the medium A1 this invention medium A2 and conventionally. After recording a signal on a medium A1 this invention medium A2 and conventionally by the single magnetic pole head, by Helmholtz coils, the direct-current magnetic field was impressed to the medium in the range of size 0.1-500Oe, the reproduction output before magnetic field impression and the reproduction output after magnetic field impression were measured, and the result was shown in drawing 3 . Drawing 3 shows the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. The fall of the reproduction output accompanying the demagnetization of record magnetization is conventionally seen in the stage which impressed 0.1Oe(s) by which a medium A1 is equivalent to the coercive force of a ground soft-magnetism film so that drawing 3 may show. To the amount of demagnetization increasing in connection with enlarging an impression magnetic field, even if it impressed the magnetic field of 500Oe(s), demagnetization was not seen, but as for this invention medium A2, it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium A2. Moreover, by the method of reading the signal recorded with ID head by the MR head, when the same experiment was conducted, the completely same inclination was seen. This result is shown in drawing 4 .

The result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the FeSiAl film at the room temperature in a ground for a reason which drawing 2 explained by the way also in this case will become the same. However, since the FeSiAl film which formed membranes at the room temperature has coercive force as large as 300Oe(s), distortion produces it in a square wave-like reproduction wave. In order to function as a ground soft-magnetism layer of a perpendicular two-layer medium and to acquire a rectangle-like reproduction wave, as for the coercive force of the ground soft-magnetism film FeSiAl, it is desirable that they are 100 or less Oes.

[0022] Next, the reproduction output was measured, while the single magnetic pole head had been made to load on a medium in order to investigate aging of record magnetization, after recording a signal on a medium A1 by the single magnetic pole head this invention medium A2 and conventionally. The reproduction output immediately after record is made into  $t = 1$  second, and it is  $t = 1 \times 10^4$ . It measured till the second. And the reproduction output at the time of  $t = 1$  second and the reproduction output after fixed time progress were measured, and the result was shown in drawing 5. Drawing 5 shows the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. By this invention medium A2, the fall of such a reproduction output was not conventionally seen for the medium A1 at all to a reproduction output declining in proportion almost ] to the logarithm of the elapsed time after signal record so that drawing 5 might show. The magnetic domain wall of NiFe moves easily also by very small magnetic fields, such as earth magnetism and a motor side for disk rotation, and since it happened in the main pole of the perpendicular magnetic head, and the corresponding field, this is considered that the demagnetization of record magnetization was seen. It is thought that the FeSiAl film used for this invention medium A2 was, on the other hand, able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the FeSiAl film at the room temperature in a ground for a reason which drawing 2 explained by the way also in this case will become the same.

[0023] By using this invention medium A2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0024] Except for having formed the FeSiAlRuTi film on the substrate as a ground soft-magnetism film, like this invention medium A2 of an example 1, the vertical-magnetic-recording medium was produced and it considered as this invention medium B-2 using the example 2FeSiAlRuTi film target. Moreover, the FeSiAlRuTi film which made substrate temperature the room temperature and formed membranes for comparison of coercive force was also produced.

[0025] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the FeSiAlRuTi film of this invention medium B-2 was observed. This was the same also about the FeSiAlRuTi film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of the FeSiAlRuTi film of this invention medium B-2 on magnetic-domain-wall movement.

[0026] Next, coercive force was 0.1Oe(s) when the coercive force of the FeSiAlRuTi film of this invention medium B-2 was investigated. Moreover, the coercive force of the FeSiAlRuTi film which made substrate temperature the room temperature and formed membranes was 300Oe(s).

[0027] When the evaluation examination of record reproducing characteristics was performed about this invention medium B-2 and it compared with the medium A1 conventionally, like this invention medium A2 of an example 1, this invention medium B-2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this evaluation examination was performed by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen.

[0028] This shows that generating of the noise of outbreak nature is fundamentally solvable, in order that the ground soft-magnetism film FeSiAlRuTi of this invention medium B-2 may not take magnetic-domain-wall structure. Moreover, the result of the medium which has the film which formed the FeSiAlRuTi film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0029] Next, the stability of the record magnetization to the external suspension magnetic field of this invention medium B-2 was measured, and it was conventionally shown in drawing 6 as contrasted with the medium A1. Drawing 6 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Even if this invention medium B-2 impressed the magnetic field of 500Oe(s) to the medium A1 conventionally to which a reproduction output falls so that drawing 6 might show, demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium B-2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 7. Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the FeSiAlRuTi film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0030] Next, aging of record magnetization was measured and it was conventionally shown in drawing 8 as contrasted with the medium A1. Drawing 8 shows the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. By this invention medium B-2, the fall of such a reproduction output was not seen at all to the medium A1 conventionally to which a reproduction output falls so that drawing 8 might show. It is thought that the FeSiAlRuTi film which

uses this for this invention medium B-2 was able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the FeSiAlRuTi film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0031] By using this invention medium B-2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0032] Using the example 3FeTaN film target, except for having formed the FeTaN film on the substrate as a ground soft-magnetism film, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium Q2. Moreover, the FeTaN film which made substrate temperature the room temperature and formed membranes for comparison of coercive force was also produced.

[0033] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the FeTaN film of this invention medium Q2 was observed. This was the same also about the FeTaN film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a FeTaN film on magnetic-domain-wall movement.

[0034] Next, coercive force was 0.1Oe(s) when the coercive force of this invention medium Q2FeTaN film was measured. Moreover, the coercive force of the FeTaN film which made substrate temperature the room temperature and formed membranes was 300Oe(s).

[0035] When the evaluation examination of record reproducing characteristics was performed about this invention medium Q2 and the envelope property with a medium A1 was compared this invention medium Q2 and conventionally, like this invention medium A2 of an example 1, this invention medium Q2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this examination was performed by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. This shows that generating of the noise of outbreak nature is fundamentally solvable, in order that the ground soft-magnetism film FeTaN of this invention medium Q2 may not take magnetic-domain-wall structure. Moreover, the result of the medium which has the film which formed the FeTaN film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0036] Next, the stability of the record magnetization to the external suspension magnetic field of this invention medium Q2 was measured, and it was conventionally shown in drawing 52 as contrasted with the medium A1. Drawing 52 shows the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. As drawing 52 shows, conventionally to which a reproduction output falls, to a medium A1, even if it impressed the magnetic field of 500Oe(s), demagnetization was not seen, but, as for this invention medium Q2, it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium Q2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 53. Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the FeTaN film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0037] Next, aging of record magnetization of this invention medium Q2 was measured, and it was conventionally shown in drawing 54 as contrasted with the medium A1. Drawing 54 shows the reproduction output after fixed time progress to \*\* and the reproduction output at the time of  $t = 1$  second by percentage. By this invention medium Q2, the fall of such a reproduction output was not seen at all to the medium A1 conventionally to which a reproduction output falls so that drawing 54 might show. It is thought that the FeTaN film used for this invention medium Q2 was able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the FeTaN film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same. By using this invention medium Q2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0038] The volume ratio of Co in an example 4 distribution film is set up to about 50%, and it is Co target and SiO<sub>2</sub>. Using a target, impressing bias voltage to a substrate on the same membrane formation conditions as an example 1 simultaneous -- a sputter -- carrying out -- a substrate top -- the Co-SiO<sub>2</sub> distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium C2. Moreover, the Co-SiO<sub>2</sub> distribution film which made substrate temperature the room temperature and formed membranes for comparison of coercive force was also produced.

[0039] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the Co-SiO<sub>2</sub> distribution film was observed. This was the same also about the Co-SiO<sub>2</sub> distribution film which made substrate temperature the room temperature and formed membranes. It is shown to the above thing being a magnetization process according [ the magnetization process of a NiFe film ] to magnetic-domain-wall movement that the magnetization process of the Co-SiO<sub>2</sub> distribution film of this invention medium C2 is not based on

magnetic-domain-wall movement.

[0040] Next, when the coercive force of a Co-SiO<sub>2</sub> distribution film was measured, the coercive force of the Co-SiO<sub>2</sub> distribution film which the Co-SiO<sub>2</sub> distribution film of this invention medium C2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0041] When the evaluation examination of record reproducing characteristics was performed about this invention medium C2 and the envelope property with a medium A1 was compared this invention medium C2 and conventionally, like this invention medium A2 of an example 1, this invention medium C2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the Co-SiO<sub>2</sub> distribution film this [ whose ] is the ground soft-magnetism film of this invention medium C2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the Co-SiO<sub>2</sub> distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0042] Next, the stability of the record magnetization to the external suspension magnetic field of this invention medium C2 was measured, and it was conventionally shown in drawing 9 as contrasted with the medium A1. Drawing 9 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 9 shows, even if this invention medium C2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium C2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 10. Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the Co-SiO<sub>2</sub> distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0043] Next, aging of record magnetization of this invention medium C2 was measured, and it was conventionally shown in drawing 11 as contrasted with the medium A1. Drawing 11 has shown the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. By this invention medium C2, the fall of such a reproduction output was not seen at all to the medium A1 conventionally to which a reproduction output falls so that drawing 11 might show. It is thought that the Co-SiO<sub>2</sub> distribution film which uses it for this invention medium B-2 was able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the Co-SiO<sub>2</sub> distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same. By using this invention medium C2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0044] while setting up the volume ratio of Co in an example 5 distribution film to about 50% and impressing bias voltage to a substrate using Co target and C target -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- a Co-C distribution film -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium D2

[0045] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the Co-C distribution film of this invention medium D2 was observed. This was the same also about the Co-C distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a Co-C distribution film on magnetic-domain-wall movement.

[0046] When the coercive force of a Co-C distribution film was investigated, the coercive force of the Co-C distribution film which the Co-C distribution film of this invention medium D2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0047] When the evaluation examination of record reproducing characteristics was performed about this invention medium D2 and the envelope property with a medium A1 was compared this invention medium D2 and conventionally, like this invention medium A2 of an example 1, this invention medium D2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the Co-C distribution film this [ whose ] is the ground soft-magnetism film of this invention medium D2 may not take magnetic-domain structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the Co-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0048] The stability of the record magnetization to the external suspension magnetic field of this invention medium D2 was measured, and it was conventionally shown in drawing 12 as contrasted with the medium A1. Drawing 12 has shown the

reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. As drawing 12 shows, conventionally to which a reproduction output falls, to a medium A1, even if it impressed the magnetic field of 500Oe(s), demagnetization was not seen, but, as for this invention medium D2, it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium D2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 13. Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the Co-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0049] Aging of record magnetization of this invention medium D2 was measured, and it was conventionally shown in drawing 14 as contrasted with the medium A1. Drawing 14 has shown the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium D2, the fall of such a reproduction output was not seen at all so that drawing 14 might show. It is thought that the Co-C distribution film used for this invention medium D2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the Co-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same. By using this invention medium D2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0050] The volume ratio of CoPt in an example 6 distribution film is set up to about 50%, and it is a CoPt target and SiO<sub>2</sub>. Using a target, impressing bias voltage to a substrate on the same membrane formation conditions as an example 1 simultaneous -- a sputter -- carrying out -- a substrate top -- the CoPt-SiO<sub>2</sub> distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it took this invention medium E2

[0051] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the CoPt-SiO<sub>2</sub> distribution film was observed. This was the same also about the CoPt-SiO<sub>2</sub> distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a CoPt-SiO<sub>2</sub> distribution film on magnetic-domain-wall movement.

[0052] When the coercive force of a CoPt-SiO<sub>2</sub> distribution film was measured, the coercive force of the CoPt-SiO<sub>2</sub> distribution film which the CoPt-SiO<sub>2</sub> distribution film of this invention medium E2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0053] When the evaluation examination of record reproducing characteristics was performed about this invention medium E2 and the envelope property with a medium A1 was compared this invention medium E2 and conventionally, like this invention medium A2 of an example 1, this invention medium E2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the CoPt-SiO<sub>2</sub> distribution film this [ whose ] is the ground soft-magnetism film of this invention medium E2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the CoPt-SiO<sub>2</sub> distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0054] The stability of the record magnetization to the external suspension magnetic field of this invention medium E2 was measured, and it was conventionally shown in drawing 15 as contrasted with the medium A1. Drawing 15 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 15 shows, even if this invention medium E2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium E2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 16. Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the CoPt-SiO<sub>2</sub> distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0055] Next, aging of record magnetization of this invention medium D2 was measured, and it was conventionally shown in drawing 17 as contrasted with the medium A1. Drawing 17 has shown the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium E2, the fall of such a reproduction output was not seen at all so that drawing 17 might show. It is thought that the CoPt-SiO<sub>2</sub> distribution film used for this invention medium E2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the CoPt-SiO<sub>2</sub> distribution film at the room temperature in a ground for a reason which the example 1 explained by the

way will become the same. By using this invention medium E2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0056] while setting up the volume ratio of CoPt in an example 7 distribution film to about 50% and impressing bias voltage to a substrate using a CoPt target and C target -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- the CoPt-C distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium F2

[0057] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the CoPt-C distribution film was observed. This was the same also about the CoPt-C distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a CoPt-C distribution film on magnetic-domain-wall movement.

[0058] Next, when the coercive force of a CoPt-C distribution film was measured, the coercive force of the CoPt-C distribution film which the coercive force of this invention medium F2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0059] When the evaluation examination of the record reproducing characteristics of this invention medium F2 was performed and the envelope property of a medium A1 was investigated this invention medium F2 and conventionally, like this invention medium A2, this invention medium F2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the CoPt-C distribution film this whose ] is the ground soft-magnetism film of this invention medium F2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the CoPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0060] The stability of the record magnetization to the external suspension magnetic field of this invention medium F2 was measured, and it was conventionally shown in drawing 18 as contrasted with the medium A1. Drawing 18 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 18 shows, even if this invention medium F2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium F2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 19.

[0061] Next, aging of record magnetization of this invention medium F2 was measured, and it was conventionally shown in drawing 20 as contrasted with the medium A1. Drawing 20 has shown the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium F2, the fall of such a reproduction output was not seen at all so that drawing 20 might show. It is thought that the CoPt-C distribution film used for this invention medium F2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the CoPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0062] By using this invention medium F2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0063] the volume ratio of CoCrPt in an example 8 distribution film -- about 50% -- setting up -- a CoCrPt target and SiO<sub>2</sub> while impressing bias voltage to a substrate using a target -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- CoCrPt-SiO<sub>2</sub> of 500nm of thickness a distributed film -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium G

[0064] CoCrPt-SiO<sub>2</sub> Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the distributed film was observed. This was the same also about the CoCrPt-SiO distribution film which made substrate temperature the room temperature and formed membranes. The above thing is CoCrPt-SiO<sub>2</sub>. It is shown that the magnetization process of a distributed film is not based on magnetic-domain-wall movement.

[0065] Next, CoCrPt-SiO<sub>2</sub> It is CoCrPt-SiO<sub>2</sub> which the coercive force of this invention medium G2 made 0.1Oe(s) and substrate temperature the room temperature when the coercive force of a distributed film was measured, and formed membranes. The coercive force of a distributed film was 300Oe(s).

[0066] When the evaluation examination of the record reproducing characteristics of this invention medium G2 was performed

and the envelope property of a medium A1 was investigated this invention medium F2 and conventionally, like this invention medium A2, this invention medium F2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. This is CoCrPt-SiO<sub>2</sub> which is the ground soft-magnetism film of this invention medium G2. In order that a distributed film may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, it is CoCrPt-SiO<sub>2</sub> by reason which the example 1 explained by the way. The result of the medium which has the film which formed the distributed film at the room temperature in a ground will also become the same.

[0067] The stability of the record magnetization to the external suspension magnetic field of this invention medium G2 was measured, and it was conventionally shown in drawing 21 as contrasted with the medium A1. Drawing 21 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 21 shows, even if this invention medium G2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium G2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 22.

[0068] Next, aging of record magnetization of this invention medium G2 was measured, and it was conventionally shown in drawing 23 as contrasted with the medium A1. Drawing 23 has shown the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium G2, the fall of such a reproduction output was not seen at all so that drawing 23 might show. CoCrPt-SiO<sub>2</sub> used for this invention medium F2 It is thought that the distributed film was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, it is CoCrPt-SiO<sub>2</sub> by reason which the example 1 explained by the way. The result of aging of record magnetization of the medium which has the film which formed the distributed film at the room temperature in a ground will become the same.

[0069] By using this invention medium G2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0070] while setting up the volume ratio of CoCrPt in an example 9 distribution film to about 50% and impressing bias voltage to a substrate using a CoCrPt target and C TA-GETTO \*\* -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- the CoCrPt-C distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium H2

[0071] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the CoCrPt-C distribution film was observed. This was the same also about the CoCrPt-C distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a CoCrPt-C distribution film on magnetic-domain-wall movement.

[0072] Next, when the coercive force of a CoCrPt-C distribution film was measured, the coercive force of the CoCrPt-C distribution film which the coercive force of the CoCrPt-C distribution film of this invention medium H2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0073] When the evaluation examination of the record reproducing characteristics of this invention medium H2 was performed and the envelope property of a medium A1 was investigated this invention medium H2 and conventionally, like this invention medium A2, this invention medium H2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the CoCrPt-C distribution film this whose ] is the ground soft-magnetism film of this invention medium H2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the CoCrPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0074] The stability of the record magnetization to the external suspension magnetic field of this invention medium H2 was measured, and it was conventionally shown in drawing 24 as contrasted with the medium A1. Drawing 24 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 24 shows, even if this invention medium H2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium H2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 25. Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the CoCrPt-C

distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0075] Next, aging of record magnetization of this invention medium H2 was measured, and it was conventionally shown in drawing 26 as contrasted with the medium A1. Drawing 26 has shown the reproduction output after fixed time progress to the reproduction output at the time of  $t = 1$  second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium H2, the fall of a reproduction output like a medium A1 before was not seen at all so that drawing 26 might show. It is thought that the CoCrPt-C distribution film used for this invention medium H2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the CoCrPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0076] By using this invention medium H2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0077] The volume ratio of CoPt in an example 10 distribution film is set up to about 50%, and it is a CoPt target and SiO<sub>2</sub> by the spatter. A spatter is simultaneously carried out on the following membrane formation conditions, impressing bias to a substrate using a target, and it is CoPt-SiO<sub>2</sub> of 500nm of thickness. Membranes were formed on the 2.5 inches substrate by using a distributed film as a ground soft-magnetism film.

Initial degree of vacuum of a membrane formation condition chamber :  $5 \times 10^{-7}$  or less mTorr injection power : 0.5kw argon gas pressure : 4mTorr substrate temperature : 600-degree-C membrane formation speed : 3 nm/sec [0078] Co<sub>65</sub>Cr<sub>35</sub> (at%) A target and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> (at%) A target is used and it is CoPt-SiO<sub>2</sub>. Co<sub>65</sub>Cr<sub>35</sub> film was formed by thickness 0, 10, 20, and 50, 100 and 120nm at the substrate temperature of 200 degrees C on the distributed film, respectively, and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film was continuously formed by 100nm of thickness on it. And the medium which formed 10nm of C protective coats, used as this invention medium J2 the medium which set Co<sub>65</sub>Cr<sub>35</sub> film to 100nm, and set Co<sub>65</sub>Cr<sub>35</sub> film to 0nm, namely, has not prepared Co<sub>65</sub>Cr<sub>35</sub> film on it further was conventionally used as the medium B1.

[0079] In order to evaluate the property of this invention medium J2, surface smooth nature, a perpendicular stacking tendency, holding power, record reproducing characteristics, etc. were measured by the following evaluation methods. The same evaluation method was applied also to the 11 or less-example example. The surface smooth nature Ra of Co<sub>65</sub>Cr<sub>35</sub> film of this invention medium J2 was measured under the magnetic-force microscope (AFM), and the result shown in drawing 27 was obtained. It is the value 2 at the time of 0nm of thickness, i.e., CoPt-SiO<sub>2</sub>. It is the value of Ra of a distributed film front face. As drawing 27 shows, it turns out that Ra reduces [ the thickness of Co<sub>65</sub>Cr<sub>35</sub> film ] 10-100nm, and there is an improvement effect of surface smooth nature. However, if 100nm of thickness is exceeded, surface smooth nature will get worse.

[0080] In order to investigate the perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film which has Co<sub>65</sub>Cr<sub>35</sub> film of 0-120nm thickness directly under Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film, the X diffraction was used, it asked for the half-value width of the rocking curve of a hcp (002) peak, and the result shown in drawing 28 was obtained. As drawing 28 shows, it turns out that the half-value width of a rocking curve falls and the perpendicular stacking tendency of 10-100nm of thickness of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film is improving. CoPt-SiO<sub>2</sub> Not perpendicular magnetic anisotropy films with Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> perfect film on a distributed film but a 10 to 20nm initial layer exists. [ in the initial stage of film formation ] However, since the crystal structure of Co<sub>65</sub>Cr<sub>35</sub> film and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film is very near, the film which was excellent in the strong crystal stacking tendency of a perpendicular anisotropy from the initial stage of film formation of perpendicular magnetic anisotropy films is formed. However, if 100nm of thickness is exceeded, the half-value width of a rocking curve will increase and the perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film will get worse.

[0081] Interlayer Co<sub>65</sub>Cr<sub>35</sub> film has the both sides of the improvement effect of the smooth nature of a CoPt-SiO<sub>2</sub> distribution film front face, and the improvement effect of the perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film so that the above thing may show.

[0082] Next, Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> which has Co<sub>65</sub>Cr<sub>35</sub> film of 0-120nm thickness directly under Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film Membranous magnetic properties were investigated by the Kerr effect measuring device, and the remanence ratio of a major company-loop as shown in drawing 29 was obtained. A remanence ratio is improved for the thickness of Co<sub>65</sub>Cr<sub>35</sub> film with the increase in thickness to 10-100nm so that drawing 29 may show. However, if 100nm of thickness is exceeded, a remanence ratio will fall.

[0083] The evaluation examination of record reproducing characteristics was performed about the medium B1 using the ID/MR combined head this invention medium J2 and conventionally. here -- the recording track width of face of a head -- 4 micrometers regenerative-track width of face -- 3 micrometers record gap length -- 0.4 micrometers reproduction gap length -- 0.32 micrometers it is . Evaluation was performed under conditions of record current 10mAop, 12mA of sense current, peripheral-velocity 12.7 m/sec, 45nm of flying heights, and 45MHz of band bands of a noise. Drawing 30 shows the recording density dependency of a medium noise. this invention medium J2 has a medium noise conventionally smaller than this in all recording density as compared with a medium B1, and it turns out that noise figure is very excellent. That is, it is CoPt-SiO<sub>2</sub> by inserting Co<sub>65</sub>Cr<sub>35</sub> interlayer. It was attained simultaneously, and the improvement of the smooth nature of a distributed film front face and the improvement of the perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film could raise the remanence ratio of the magnetic properties of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> perpendicular magnetic anisotropy films, could reduce the thickness of an initial layer, and led to low noise-ization. A result with Co<sub>65</sub>Cr<sub>35</sub> interlayer's thickness same [ a medium 100nm or less ] is obtained.

[0084] Drawing 31 is medium S/N. A recording density dependency is shown. 2-5dB of medium S/N is good, and this shows [ in / all recording density / a medium B1 / conventionally / in this invention medium J2 ] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium K2.

[0085] The volume ratio of CoCrPt in an example 11 distribution film is set up to about 50%, and it is a CoCrPt target and SiO<sub>2</sub>. It removes having used the target and is CoCrPt-SiO<sub>2</sub> of 500nm of thickness at the same membrane formation conditions as an example 10. Membranes were formed on the substrate by using a distributed film as a ground soft-magnetism film. Subsequently, Ti target and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> (at%) A target is used and it is CoCrPt-SiO<sub>2</sub>. Ti film was formed by thickness 0, 10, 20, and 50, 100 and 120nm at the substrate temperature of 200 degrees C on the distributed film, and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film was continuously formed by 100nm of thickness on Ti film. And the medium which formed 10nm of C protective coats, used as this invention medium K2 the medium which set Ti film to 100nm, and set Ti film to 0nm, namely, has not prepared Ti film on Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film further was conventionally used as the medium C1.

[0086] The surface smooth nature Ra of Ti film was measured, and the result shown in drawing 32 was obtained. It is the value 2 at the time of 0nm of thickness, i.e., CoCrPt-SiO<sub>2</sub>. It is the value of Ra of a distributed film front face. As drawing 32 shows, it turns out that Ra reduces [ the thickness of Ti film ] 10-100nm, and there is an improvement effect of surface smooth nature. However, if 100nm of thickness is exceeded, surface smooth nature will get worse.

[0087] The perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film which has Ti film of 0-120nm thickness directly under Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film was investigated, and the result shown in drawing 33 was obtained. As drawing 33 shows, it turns out that the half-value width of a rocking curve falls and the perpendicular stacking tendency of 10-100nm of thickness of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film is improving. CoCrPt-SiO<sub>2</sub> Not perpendicular magnetic anisotropy films with Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> perfect film on a distributed film but a 10 to 20nm initial layer exists. [ in the initial stage of film formation ] However, since Ti film and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film have good grid adjustment, the film which was excellent in the strong crystal stacking tendency of a perpendicular anisotropy from the initial stage of film formation of perpendicular magnetic anisotropy films is formed. However, if 100nm of thickness is exceeded, the half-value width of a rocking curve will increase and the perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film will get worse. An interlayer Ti film is CoCrPt-SiO<sub>2</sub> so that the above thing may show. It has the both sides of the improvement effect of the smooth nature of a distributed film front face, and the improvement effect of the perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film.

[0088] Next, the magnetic properties of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film which has Ti film of 0-120nm thickness directly under Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film were investigated, and the result shown in drawing 34 was obtained. A remanence ratio is improved for the thickness of Ti film with the increase in thickness to 10-100nm so that drawing 34 may show. However, if 100nm of thickness is exceeded, a remanence ratio will fall.

[0089] The evaluation examination of the record reproducing characteristics of a medium C1 was performed this invention medium K2 and conventionally, and the result of the recording density dependency of a medium noise shown in drawing 35 was obtained. this invention medium K2 has a conventionally small medium noise in all recording density as compared with a medium C1, and it turns out that noise figure is very excellent. That is, it is CoCrPt-SiO<sub>2</sub> by inserting Ti interlayer. It was attained simultaneously, and the improvement of the smooth nature of a distributed film front face and the improvement of the perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film could raise the remanence ratio of the magnetic properties of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> perpendicular magnetic anisotropy films, could reduce the thickness of an initial layer, and led to low noise-ization. A result with Ti interlayer's thickness same [ a medium 100nm or less ] is obtained from the above thing.

[0090] Drawing 36 shows the recording density dependency of medium S/N. 1-2dB of medium S/N is good, and this shows [ in / all recording density / a medium C1 / conventionally / in this invention medium K2 ] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium K2.

[0091] The volume ratio of CoCrPt in an example 12 distribution film was set up to about 50%, and membranes were formed on the substrate on the same membrane formation conditions as an example 10 except for having used the CoCrPt target and C target by using the CoCrPt-C distribution film of 500nm of thickness as a ground soft-magnetism film. Subsequently, Cr<sub>20</sub>Ti<sub>80</sub> target and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> (at%) Using the target, Cr<sub>20</sub>Ti<sub>80</sub> film was formed by thickness 0, 10, 20, and 50, 100 and 120nm at the substrate temperature of 200 degrees C on the CoCrPt-C distribution film, and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film was further formed by 100nm of thickness on Cr<sub>20</sub>Ti<sub>80</sub> film continuously. Subsequently, the medium which formed 10nm of C protective coats, used as this invention medium L2 the medium which set Cr<sub>20</sub>Ti<sub>80</sub> film to 100nm, and set Cr<sub>20</sub>Ti<sub>80</sub> film to 0nm, namely, has not prepared Ti film on Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film was conventionally used as the medium D1.

[0092] The surface smooth nature Ra of Cr<sub>20</sub>Ti<sub>80</sub> film was measured, and the result shown in drawing 37 was obtained. It is the value of Ra of the value at the time of 0nm of thickness, i.e., a CoCrPt-C distribution film front face. As drawing 37 shows, it turns out that Ra reduces [ the thickness of Cr<sub>20</sub>Ti<sub>80</sub> film ] 10-100nm, and there is an improvement effect of surface smooth nature. However, if 100nm of thickness is exceeded, surface smooth nature will get worse.

[0093] The perpendicular stacking tendency of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film which has Cr<sub>20</sub>Ti<sub>80</sub> film of 0-120nm thickness directly under Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film was investigated, and the result shown in drawing 38 was obtained. As drawing 38 shows, it turns out that the half-value width of a rocking curve falls and the perpendicular stacking tendency of 10-100nm of thickness of Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film is improving. Not perpendicular magnetic anisotropy films with Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> perfect film on a CoCrPt-C distribution film but a 10 to 20nm initial layer exists. [ in the initial stage of film formation ] However, since Cr<sub>20</sub>Ti<sub>80</sub> film and Co<sub>78</sub>Cr<sub>19</sub>Ta<sub>3</sub> film have good grid adjustment, the film which was excellent in the strong crystal stacking tendency of a perpendicular

anisotropy from the initial stage of film formation of perpendicular magnetic anisotropy films is formed. However, if 100nm of thickness is exceeded, the half-value width of a rocking curve will increase and the perpendicular stacking tendency of Co78Cr19Ta3 film will get worse. Interlayer Cr20Ti80 film has the both sides of the improvement effect of the smooth nature of a CoCrPt-C distribution film front face, and the improvement effect of the perpendicular stacking tendency of Co78Cr19Ta3 film so that the above thing may show.

[0094] Next, the magnetic properties of Co78Cr19Ta3 film which has Cr20Ti80 film of 0-120nm thickness directly under Co78Cr19Ta3 film were investigated, and the result shown in drawing 39 was obtained. A remanence ratio is improved for the thickness of Cr20Ti80 film with the increase in thickness to 10-100nm so that drawing 39 may show. However, if 100nm of thickness is exceeded, a remanence ratio will fall.

[0095] The evaluation examination of the record reproducing characteristics of a medium D1 was performed this invention medium L2 and conventionally, and the result of the recording density dependency of a medium noise shown in drawing 40 was obtained. this invention medium L2 has a medium noise conventionally smaller than this in all recording density as compared with a medium D1, and it turns out that noise figure is very excellent. That is, by inserting Cr20Ti80 interlayer, it was attained simultaneously, and the improvement of the smooth nature of a CoCrPt-C distribution film front face and the improvement of the perpendicular stacking tendency of Co78Cr19Ta3 film could raise the remanence ratio of the magnetic properties of Co78Cr19Ta3 perpendicular magnetic anisotropy films, could reduce the thickness of an initial layer, and led to low noise-ization. Moreover, a result with Cr20Ti80 interlayer's thickness same [ a medium 100nm or less ] is obtained.

[0096] Drawing 41 shows the recording density dependency of medium S/N. 1-4dB of medium S/N is good, and this shows [ in / all recording density / a medium D1 / conventionally / in this invention medium L2 ] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium L2.

[0097] Cr target was used at the substrate temperature of 600 degrees C by the spatter on the substrate of 132.5 inches of examples, and Cr film was formed by thickness 0, 100, 200, 300, and 400 and 500nm. Subsequently, it is CoPt-SiO2 of 500nm of thickness on Cr film like an example 10. Distributed film, Co78Cr19Ta3 film of 100nm of thickness and C protective coat of 10nm of thickness are formed. The medium which inserted Cr film of 500nm thickness is used as this invention medium M2, and Cr film is not inserted, but it is CoPt-SiO2. The medium which formed the distributed film and Co78Cr19Ta3 film was conventionally used as the medium E1.

[0098] Next, CoPt-SiO2 with Cr ground A distributed film and CoPt-SiO2 which it does not have The coercive force of a distributed film was measured using the sample oscillatory-type magnetometer (VSM), and the result shown in drawing 42 was obtained. It follows on the increase in the thickness of Cr ground so that drawing 42 may show, and it is CoPt-SiO2. The coercive force of a distributed film increases.

[0099] On the same reproduction conditions as an example 10, the evaluation examination of the record reproducing characteristics of a medium E1 was performed this invention medium M2 and conventionally, and the recording density dependency of a medium noise shown in drawing 43 was acquired. The medium E1 is standardized this invention medium M2 and conventionally by the output value (output value at the time of recording density 10kFRPI in this case) of a solitary wave. this invention medium M2 has attenuation of the output accompanying increase of recording density conventionally slower than this as compared with a medium E1. In other words, this invention medium M2 can obtain the output conventionally higher than a medium E1 to high recording density. CoPt-SiO2 By inserting Cr ground in the bottom of a distributed film, coercive force increased and improvement in the record density dependence of an output was attained.

[0100] Drawing 44 shows the value of medium S/N in recording density 400kFRPI. About 2dB of medium S/N is good, and this shows [ in / high recording density / a medium E1 / conventionally / in this invention medium M2 ] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium M2.

[0101] Replace with Cr film of example 14 example 13, and using V target, form membranes by thickness 0,100,200,300,400 and 500nm, respectively, and, subsequently V film is made to be the same as that of an example 11. A vertical-magnetic-recording medium is produced, the medium which inserted V film of 500nm thickness is used as this invention medium N2, and V film is not inserted, but it is CoCrPt-SiO2. The medium which formed the distributed film and Co78Cr19Ta3 film was conventionally used as the medium F1.

[0102] Next, CoCrPt-SiO2 with V ground as well as an example 13 A distributed film and CoCrPt-SiO2 which it does not have The coercive force of a distributed film was measured and the result shown in drawing 45 was obtained. It follows on the increase in the thickness of V ground so that drawing 45 may show, and it is CoCrPt-SiO2. The coercive force of a distributed film increases.

[0103] Like the example 13, the evaluation examination of the record reproducing characteristics of a medium F1 was performed this invention medium N2 and conventionally, and the recording density dependency of a medium noise shown in drawing 46 was acquired. The medium F1 is standardized this invention medium N2 and conventionally by the output value (output value at the time of recording density 10kFRPI in this case) of a solitary wave. this invention medium N2 has attenuation of the output accompanying increase of recording density conventionally slower than this as compared with a medium F1. In other words, this invention medium N2 can obtain the output conventionally higher than a medium F1 to high recording density. CoCrPt-SiO2 By inserting V ground in the bottom of a distributed film, coercive force increased and improvement in the record density dependence of an output was attained.

[0104] Drawing 47 shows the value of medium S/N in recording density 400kFRPI. About 2dB of medium S/N is good, and this

shows [ in / high recording density / a medium F1 / conventionally / in this invention medium N2 ] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium M2.

[0105] Replace with Cr film of example 15 example 13, and using Cu target, form membranes by thickness 0,100,200,300,400 and 500nm, respectively, and, subsequently Cu film is made to be the same as that of an example 12. The vertical-magnetic-recording medium was produced, the medium which inserted Cu film of 500nm thickness was used as this invention medium P2, and the medium which formed the CoCrPt-C distribution film and Co78Cr19Ta3 film was conventionally used as the medium G1, without inserting Cu film.

[0106] Next, the coercive force of a CoCrPt-C distribution film with Cu ground and the CoCrPt-C distribution film which it does not have was investigated like the example 13, and the result shown in drawing 48 was obtained. The coercive force of a CoCrPt-C distribution film increases with the increase in the thickness of Cu ground so that drawing 48 may show.

[0107] Like the example 13, the evaluation examination of the record reproducing characteristics of a medium G1 was performed this invention medium P2 and conventionally, and the result of the recording density dependency of a medium noise shown in drawing 49 was obtained. The medium G1 is standardized this invention medium P2 and conventionally by the output value (output value at the time of recording density 10kFRPI in this case) of a solitary wave. this invention medium P2 has attenuation of the output accompanying increase of recording density conventionally slower than this as compared with a medium G1. In other words, this invention medium P2 can obtain the output conventionally higher than a medium G1 to high recording density. By inserting Cu ground in the bottom of a CoCrPt-C distribution film, coercive force increased and improvement in the record density dependence of an output was attained.

[0108] Drawing 50 shows the value of medium S/N in recording density 400kFRPI. About 2dB of medium S/N is good, and this shows [ in / high recording density / a medium G1 / conventionally / in this invention medium P2 ] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium M2.

[0109]

[Effect of the Invention] According to this invention, the vertical-magnetic-recording medium which the noise of outbreak nature, the demagnetization of record magnetization, or the demagnetization phenomenon which the envelope property at the time of record reproduction is raised, and originates in movement of the magnetic domain wall of a ground soft-magnetism film does not generate is realized by preparing the ground soft-magnetism film of non-magnetic-domain-wall structure in the bottom of perpendicular magnetic anisotropy films. Thereby, conventionally, demagnetization of the record magnetization which was the fatal defect of a vertical-magnetic-recording medium, or generating of a demagnetization phenomenon could be prevented fundamentally, and the vertical-magnetic-recording medium excellent in record reproducing characteristics is realized.

[0110] According to the vertical-magnetic-recording medium given in claims 6 and 7, improvement in the surface smooth nature of a ground soft-magnetism film and improvement in the perpendicular stacking tendency of perpendicular magnetic anisotropy films can be simultaneously aimed at by inserting a junction layer between the granular thin film used as a ground soft-magnetism film, and perpendicular magnetic anisotropy films. According to this effect, the remanence ratio of the magnetic properties of perpendicular magnetic anisotropy films has been improved, low medium noise-ization could be attained, and the vertical-magnetic-recording medium excellent in record reproducing characteristics is realized.

[0111] According to the vertical-magnetic-recording medium according to claim 8, by inserting either Cr film, V film and Cu film between the granular thin films and substrates which are used as a ground soft-magnetism film, independence of the particle distributed in the base material compared with the case where Cr film, V film, and Cu film are not inserted can be promoted, and improvement in coercive force can be aimed at. According to this effect, improvement in the recording density dependency of a reproduction output could be aimed at, and the vertical-magnetic-recording medium excellent in record reproducing characteristics is realized.

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[Translation done.]

**\* NOTICES \***

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2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

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**CLAIMS**

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[Claim(s)]

[Claim 1] The vertical-magnetic-recording medium which a soft-magnetism film is formed as non-magnetic-domain-wall structure, and is characterized by the coercive force being 300 or less Oes in the vertical-magnetic-recording medium which has at least a substrate, the soft-magnetism film prepared on the substrate, and the perpendicular magnetic anisotropy films prepared on the soft-magnetism film.

[Claim 2] The vertical-magnetic-recording medium according to claim 1 by which a soft-magnetism film is characterized by being formed with FeSiAl or the FeSiAl system alloy.

[Claim 3] The vertical-magnetic-recording medium according to claim 1 by which a soft-magnetism film is characterized by being formed with FeTaN or the FeTaN system alloy.

[Claim 4] The vertical-magnetic-recording medium according to claim 1 by which a soft-magnetism film is characterized by being formed as a granular thin film.

[Claim 5] The vertical-magnetic-recording medium according to claim 4 characterized by forming the granular thin film by either of the matrix elements of the matrix which constituted as a line the material of the particle which SiO<sub>2</sub> or C is used [ particle ] as the base material of a granular thin film, and it considers [ particle ] as the material of the particle which distributes either Co, CoPt and CoCrPt in a base material, and makes a train and mother existence distribute a base material.

[Claim 6] A vertical-magnetic-recording medium given in any 1 term of the claims 1-5 to which the junction layer of 100nm or less of thickness is characterized by intervening between a soft-magnetism film and perpendicular magnetic anisotropy films.

[Claim 7] The vertical-magnetic-recording medium according to claim 6 characterized by forming the junction layer by either Co<sub>1-X</sub>Cr<sub>x</sub> (0.25≤x≤0.60), Ti and CrTi.

[Claim 8] A vertical-magnetic-recording medium given in any 1 term of the claims 4-7 to which either Cr film of 500nm or less of thickness, V film and Cu film are characterized by intervening between a granular thin film and a substrate.

[Claim 9] A vertical-magnetic-recording medium given in any 1 term of the claims 4-8 characterized by a granular thin film being non-magnetic-domain-wall structure.

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[Translation done.]